Integrated Vector Management Program

Marin/Sonoma Mosquito & Vector Control District

Draft Programmatic EIR
August 2015

State Clearinghouse No. 2012052066

MARIN/SONOMA MOSQUITO & VECTOR CONTROL DISTRICT

Protecting Public Health Since 1915

Document Information

Prepared for	Marin/Sonoma Mosquito & Vector Control District
Project Name	Integrated Vector Management Program Draft Programmatic Environmental Impact Report
Date	August 2015
State Clearinghouse No.	2012052066

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Acronyms

°C	degrees Celsius
°F	degrees Fahrenheit
µg/kg	microgram(s) per kilogram
µg/L	microgram(s) per liter
µg/m^3	microgram(s) per cubic meter
2,4-D	2,4-dichlorophenoxyacetic acid
AB	Assembly Bill
AC	alternating current
AMM	avoidance and minimization measure
APAP	Aquatic Pesticide Application Plan
APEs	alkylphenol ethoxylates
ATCM	Airborne Toxic Control Measure
ATSB	attractive toxic sugar bait
ATV	all-terrain vehicle
BAAQMD	Bay Area Air Quality Management District
Basin Plan	Water Quality Control Plan
BCDC	San Francisco Bay Conservation and Development Commission
BDCP	Bay Delta Conservation Plan
BMP	best management practice
BP	boiling point
Bs	Bacillus sphaericus
BTEX	benzene, toluene, ethylbenzene, xylenes
Bti	Bacillus thuringiensis israelensis
CAA	Clean Air Act of 1970
CAAQS	California Ambient Air Quality Standards
CAL FIRE	California Department of Forestry and Fire Protection
Cal/EPA	California Environmental Protection Agency
CAPCOA	California Air Pollution Control Officers Association
CARB	California Air Resources Board
cc	cubic centimeter(s)
CCD	colony collapse disorder
CCR	California Code of Regulations
CDC	Centers for Disease Control and Prevention
CDFA	California Department of Food and Agriculture
CDFW	California Department of Fish and Wildlife (formerly Fish and Game [CDFG])
CDPH	California Department of Public Health (formerly Health Services [CDHS])

CDPR	California Department of Pesticide Regulation
CEC	California Energy Commission
CEDEN	California Environmental Data Exchange Network
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CH_4	methane
CNDDB	California Natural Diversity Database
CNEL	Community Noise Equivalent Level
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent(s)
CWA	Clean Water Act
dB	decibel(s)
dBA	A-weighted sound level/decibel(s)
Delta	Sacramento-San Joaquin River Delta
DPM	diesel particulate matter
DPS	distinct population segment
FAA	Federal Aviation Administration
FFDCA	Federal Food, Drug, and Cosmetic Act
FHSZ	Fire Hazard Severity Zone
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
GHG	greenhouse gas
GPS	global positioning system
GWP	global warming potential
HCP	Habitat Conservation Plan
HPS	Hantavirus Pulmonary Syndrome
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
IRT	Interagency Review Team
IVM	Integrated Vector Management
IVMP/Program	Integrated Vector Management Program
LC_{50}	50 percent lethal concentration
LCAQMD	Lake County Air Quality Management District
LCSF	Low Carbon Fuel Standard
LD_{50}	50 percent lethal dose
L_{dn}	day/night average sound level
LED	light emitting diode
L_{eq}	energy-equivalent sound/noise descriptor

LOAEL	lowest observed adverse effect level
LS	less than significant
MCAQMD	Mendocino County Air Quality Management District
MCLs	Maximum Contaminant Levels
MCOSD	Marin County Open space District
MEI	Maximally Exposed Individual
mg/kg	milligram(s) per kilogram
mg/L	milligram(s) per liter
MMT	million metric tonne(s)
MMWD	Marin Municipal Water District
MRC	Mendocino Redwood Company, LLC
MRP	Monitoring and Reporting Program
MSDS	material safety data sheet
MSMVCD	Marin/Sonoma Mosquito & Vector Control District
MT	metric tonne(s)
N	no impact
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NCCP	Natural Community Conservation Plan
ng/L	nanogram(s) per liter
NMFS	National Marine Fisheries Service
NO	nitric oxide
NO_2	nitrogen dioxide
NOA	Notice of Availability
NOAA	National Oceanic and Atmospheric Administration
NOAEL	no observed adverse effect level
NOP	Notice of Preparation
NO_X	nitrogen oxides
NPDES	National Pollutant Discharge Elimination System
NSCAPCD	Northern Sonoma County Air Pollution Control District
NWR	National Wildlife Refuge
O_3	ozone
OP	organophosphate
PAHs	polycyclic aromatic hydrocarbons
PAP	Pesticide Application Plan (NPDES)
Pb	lead
PBO	piperonyl butoxide
PBT	persistent bioaccumulative toxic

PCR	polymerase chain reaction
PEIR	Programmatic Environmental Impact Report
PERP	Portable Equipment Registration Program
PHG	Public Health Goal
PILT	Payment In Lieu of Taxes
PM_{10}	respirable particulate matter
$PM_{2.5}$	fine particulate matter
POD	pelagic organism decline
POM	particulate organic matter
ppb	part(s) per billion
ppm	part(s) per million
ppmv	part(s) per million by volume
ppt	part(s) per trillion
PUP	Pesticide Use Proposal (USFWS)
RHA	Rivers and Harbors Act
RIM	rotational impoundment management
ROC	reactive organic compound
ROG	reactive organic gas
RWQCB	Regional Water Quality Control Board
SB	Senate Bill
SCP	scientific collections permit
SCWA	Solano County Water Agency
SDSs	Safety Data Sheets
SF_6	sulfur hexafluoride
SFBAAB	San Francisco Bay Area Air Basin
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SIP	State Implementation Plan
SLE	Saint Louis encephalitis
SM	potentially significant but mitigable
SO_2	sulfur dioxide
SRPCS	Santa Rosa Plain Conservation Strategy
SU	significant and unavoidable
SVOC	semivolatile organic compound
SWRCB	California State Water Resources Control Board
TMDL	total maximum daily load
ULV	ultralow volume
UNFCCC	United Nations Framework Convention on Climate Change
USACE	US Army Corps of Engineers

USC	United States Code
USDA	US Department of Agriculture
USEPA	US Environmental Protection Agency
USFS	USDA Forest Service
USFWS	US Fish and Wildlife Service
VCAPCD	Ventura County Air Pollution Control District
VOC	volatile organic compound
VVOC	Very volatile organic compound
WEE	western equine encephalomyelitis
WNV	West Nile Virus
YSAQMD	Yolo-Solano Air Quality Management District

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1 Introduction

The Marin/Sonoma Mosquito and Vector Control District (MSMVCD/the District), as Lead Agency under the California Environmental Quality Act (CEQA), has prepared this Programmatic Environmental Impact Report (PEIR) for their ongoing program of surveillance and control of mosquitoes and other vectors of human disease and discomfort.

1.1 History and Background

This section presents the history of why the District was established in 1915 to control vectors transmitting disease to humans and their domesticated animals within the District's Service Area. In 1976, Central Sonoma County was added to the Service Area, and in 2004 voters approved the annexation of the remaining territories of Marin and Sonoma counties. The section begins with a description of the diseases of concern, the potential for human and animal illness to occur, and the legislative and regulatory actions leading to the District's establishment of an Integrated (Mosquito and) Vector Management Program (IVMP or Program).

1.1.1 Vector-Borne Diseases in Program Area

The District's IVMP is designed to protect the public health from the following potential diseases organized by vector. A *vector is* an insect or other organism that transmits a pathogenic fungus, virus, bacterium, etc. such as a mosquito, tick, or rat. According to the California Health and Safety Code [Section 2002(k)], "vector" means any animal capable of transmitting the causative agent of human disease or capable of producing human discomfort or injury, including, but not limited to, mosquitoes, flies, mites, ticks, other arthropods, and rodents and other vertebrates.

1.1.1.1 Mosquitoes

Diseases of concern within the District's Service Area that are spread by mosquitoes include the following at present: West Nile virus (WNV), Western equine encephalomyelitis (WEE), St. Louis encephalitis (SLE), malaria, dog heartworm disease, and myxomatosis. The potential for the introduction of new diseases exists at any time.

1.1.1.1.1 West Nile Virus

WNV is transmitted during blood-meal feeding by mosquitoes that have previously fed on the blood of infected birds. Humans, horses, and most other mammals are all potential incidental hosts (CDC 2004a). Approximately 80 percent of people who become infected with WNV develop no clinical illnesses or symptoms and, of those who do develop symptoms, most develop what has been termed West Nile fever. Depending on the degree to which the central nervous system is affected, other more severe diseases could develop including West Nile meningitis, West Nile encephalitis, and West Nile poliomyelitis (CDC 2004b). Out of 429 reported human cases of WNV in 2012 in California, 19 persons died from the disease.

Whelan (2015) reported the following observations and hypotheses. By the end of 2014, the California Department of Public Health (CDPH) had documented 801 human cases, including 31 deaths. The rate of infection among birds was the highest to date with 60 percent of dead birds tested having WNV. California's drought is believed to be a significant factor contributing to the increasing numbers of infected mosquitoes, as both birds and mosquitoes have expanded their search for water closer to population centers, causing them to come into contact with each other more often and nearer to people. Warmer temperatures have increased the length of the mosquito season, which is another factor contributing to higher observed infection rates.

1.1.1.1.2 Western Equine Encephalomyelitis

WEE virus primarily cycles between birds and mosquitoes infecting humans and horses. Horses infected with WEE do not develop a significant viremia[1] and are true dead-end hosts, meaning the horse is a host from which infectious agents are not transmitted to other susceptible hosts.

WEE can also cycle between mosquitoes and blacktail jackrabbits. WEE usually shows no symptoms or is mild in adults, with nonspecific signs of illness and few deaths. The disease is most severe in children, particularly infants under 1 year of age. Infants under 3 months most often experience permanent, severe neurological damage. Horses can also experience asymptomatic infections or mild symptoms; however, more severe infections can occur. Horses that recover from encephalitis have a high incidence of residual symptoms (Iowa State University 2008).

1.1.1.1.3 St. Louis Encephalitis

The SLE virus is transmitted to mosquitoes while feeding on the blood of infected birds. Humans and domestic mammals can acquire SLE infection, but are dead-end hosts, hosts that do not develop a significant viremia to be passed on (CDC 2009a). Most SLE infections show no signs, with clinical infections resulting in less than 1 percent of infections that can range from mild nonspecific fever to meningitis or encephalitis. Older age increases the risk of severe disease and fatality. According to the Centers for Disease Control and Prevention (CDC 2009b), almost 90 percent of elderly persons with SLE develop encephalitis.

1.1.1.1.4 Malaria

Malaria parasites are transmitted to humans after being bitten by an infected female Anopheles mosquito. It is endemic to tropical and subtropical parts of the world where climatic factors favor mosquito and parasite development. The mosquito must have been infected by previously feeding on the blood of an infected person. Uncomplicated malaria manifests in patients as flu-like symptoms while severe malaria can cause neurologic abnormalities, anemia, kidney failure, acute respiratory distress syndrome, and hypoglycemia (CDC 2012a). The parasite is most often seen in travelers and immigrants from countries where malaria is endemic; however, outbreaks of locally transmitted cases have been observed; and due to the existence of suitable vectors, the potential risk for the disease to reemerge is present, especially in the southern states (CDC 2010a).

1.1.1.1.5 Dog Heartworm Disease

Heartworm disease is caused by a parasitic worm and results in severe lung disease, heart failure, organ damage, and death in domesticated mammals, mainly dogs and cats. Worms are spread through blood-meal feeding of mosquitoes, with adults maturing in the heart, lungs, and associated blood vessels. The severity of heartworm disease is correlated to how many worms are living inside the animal, how long the animal has been infected, and the animal's response to the heartworms' presence. Signs of the disease can range from no symptoms to tiredness, coughing, and heart failure. The most severe cases are known as caval syndrome in which blood flow to the heart is blocked by a large worm mass. If left untreated, heartworm disease will progress and damage to internal organs will eventually cause death. In some rare cases, humans have contracted heartworms after being bitten by an infected mosquito; however, larvae usually die before they can migrate to the heart or lungs (United States Food and Drug Administration 2010).

1.1.1.1.6 Myxomatosis

Myxomatosis is a fatal disease of domesticated rabbits caused by the myxoma virus, characterized by mucinous skin lesions. In the United States, the disease is restricted to coastal areas of California and

[1] Viremia is a medical condition where viruses enter the bloodstream and, hence, have access to the rest of the body.

Oregon. Outbreaks occur infrequently but sporadic cases are common. Transmission occurs through the biting of blood-sucking insects, such as mosquitoes, fleas, and biting flies, as well as direct contact. Initial signs of the disease are conjunctivitis and milky discharge from the eyes, progressing to swelling of the face with discharge coming from the nasal cavity. Eventually breathing becomes labored and the rabbit will go into coma just before dying (McClure 2011).

1.1.1.2 Other Insect Vectors

Other insect vectors of concern to the District are ticks and yellow jackets wasps.

1.1.1.2.1 Lyme Disease

This disease is caused by Lyme disease bacterium and is spread by the bite of infected ticks. Immature nymph ticks most commonly infect humans since they are tiny and difficult to see. Dogs and cats can contract Lyme disease and bring infected ticks in close contact with pet owners (CDC 2013a). Early signs of the bacteria are a red, expanding rash, flu-like symptoms, and swollen lymph nodes. Untreated, the disease can cause inflammation in a variety of tissues in the body including joints, face, spinal cord, and heart. Approximately 10 to 20 percent of patients with Lyme disease have symptoms that worsen and last months to years. This condition is known as Post-treatment Lyme Disease syndrome and is thought to be an autoimmune response (CDC 2013b). In the United States, most infections occur in the northeast and mid-Atlantic, north central states, and northern California (CDC 2013c).

1.1.1.2.2 Babesiosis

Babesiosis is a parasitic disease caused by parasites that infect and destroy red blood cells in humans and domestic animals, mainly in parts of the northeast and upper Midwest (CDC 2012b). The life cycle of this parasite involves two hosts, a rodent, primarily the white-footed mouse, and a tick. A tick infects a mouse allowing the parasite to complete part of its life cycle. Another tick feeds on the mouse ingesting the partially developed parasite, after which that infected tick can feed on a human delivering the parasite to finish its life cycle (CDC 2012c). Many people who are infected with babesiosis develop no symptoms, while a smaller group of people develops nonspecific flu-like symptoms. The disease can be severe in people who have a compromised immune system, have another serious health condition, or are elderly. Complications can include low and unstable blood pressure, hemolytic anemia, low platelet count, and malfunction of vital organs (CDC 2012d).

1.1.1.2.3 Ehrlichiosis

Ehrlichiosis is a tick-borne bacterial infection of white blood cells caused by three bacterial species in the genus *Ehrlichia*, *E. chaffeensis*, *E. ewingii*, and *E. muris*. The tick bite in most cases is not detected due to the small size of the nymphal tick and symptoms usually develop in 1 to 2 weeks. The symptoms for this group of infections can vary greatly depending on the person, but generally they are flu-like, with 30 percent of adults and 60 percent of children developing rashes (CDC 2011a). Immune-compromised people could experience a more severe case of ehrlichiosis with the fatality rate of those infected being approximately 1.8 percent. The disease is most commonly reported in the southeastern and southcentral United States (CDC 2011b).

1.1.1.2.4 Rocky Mountain Spotted Fever

Rocky Mountain spotted fever is a tick-borne disease caused by the bacterium *Rickettsia rickettsii*. The bacterium infects the endothelial cells that line the blood vessels. Symptoms are similar to other tick-borne diseases, generally flu-like with 90 percent of cases having an associated rash. Patients who have a severe infection can have long-term health complications where damage to the brain or other vital organs from bleeding or clotting may occur (CDC 2010b). According to the CDC, from 2000 to 2010 Rocky Mountain spotted fever had a fatality rate of 0.5 percent. Cases of this disease have been reported from all 50 states (CDC 2012e).

1.1.1.2.5 Anaplasmosis

Anaplasmosis is a tick-borne disease caused by the bacterium *Anaplasma phagocytophilum*. The western black-legged tick (Ixodes pacificus) is the primary vector in Northern California. The symptoms of anaplasmosis are general, nonspecific flu-like symptoms; however, rashes are rarely reported and may signify a coinfection with other tick-borne diseases. The severity of the disease depends in part on the patient's immune system condition (CDC 2012f). According to the CDC, since anaplasmosis became a reportable disease in 1999 the number of cases reported per year has increased steadily. However the case fatality rate has remained low at less than 1 percent. The disease is most frequently reported from the upper midwestern and northeastern part of the country (CDC 2012g).

1.1.1.2.6 Tularemia

Tularemia is a bacterial infection of animals and humans caused by the bacterium *Francisella tularensis*. The disease can be transmitted by tick and deer fly bites, handling infected animals, and more rarely inhaling dust or drinking water contaminated with the bacterium (CDC 2011d). Tularemia manifests itself depending on how the bacterium enters the body. Ulcers and lymph gland inflammation are common symptoms mainly from infected animal handling and insect bites. Inhaled tularemia is the most severe form causing chest pain and trouble breathing. This condition can also result from other forms of tularemia being left untreated. Rabbits and domestic cats are very susceptible to tularemia (CDC 2011e).

1.1.1.3 Mammals

1.1.1.3.1 Hantavirus

Hantavirus Pulmonary Syndrome (HPS) is a respiratory disease in humans caused by an infection with hantavirus. The *Sin Nombre* hantavirus causes the majority of cases of HPS in the United States, and the host of this virus is the deer mouse (*Peromyscus maniculatus*), although several other hantaviruses with associated hosts exist. Rodents spread the disease through their urine, droppings, and saliva. The virus is mainly transmitted through airborne transmission, with people inhaling air contaminated with the virus. Other ways people may become infected are when they touch their nose or mouth after touching something contaminated with the virus, eat something that is contaminated, and very rarely bitten by an infected rodent (CDC 2012h). Early symptoms of the viral infection are flu-like, with later symptoms of shortness of breath, evidence of the lungs filling with fluid. According to the CDC the mortality rate for HPS is 38 percent (CDC 2012i). Hemorrhagic fever with renal syndrome is another disease cause by hantavirus and is transmitted in similar ways. Early symptoms are flu-like, with some individuals developing inflammation or redness in the face. Later symptoms can include low blood pressure, acute shock, and kidney failure (CDC 2011f).

1.1.1.3.2 Plague

Plague is a disease caused by the bacterium *Yersinia pestis* that affects humans and other mammals. Bites from infected rodent fleas are the most common way of transmitting the plague (bubonic or septicemic plague); however, the bacterium can also be transmitted through contact with infected animals (septicemic plague) or breathing in infectious droplets for instance after an infected animal coughs (pneumonic plague). Cats are particularly susceptible to plague and can be infected by eating infected rodents, posing a risk to humans they come in contact with (CDC 2012j). All forms of the plague develop flu-like symptoms. With bubonic and septicemic plague swelling of lymph nodes and tissue necrosis respectively can occur near where the bacterium entered the body. Pneumonic plague is the most serious form causing shortness of breath and chest pain from bacteria spreading in the lungs. It can develop from untreated bubonic and septicemic plague and is the only form that can spread person to person (CDC 2012k).

1.1.1.3.3 Rabies

Rabies is a viral disease transmitted to humans and domestic animals through close contact with infected animals, usually saliva from bites or scratches. In the United States, bats are the most common source of human rabies deaths. Initial symptoms of rabies are generally fever and unusual sensation at the wound site. The virus then spreads through the central nervous system causing fatal inflammation of the brain and spinal cord. From here, the disease can manifest in two ways: (1) individuals with furious rabies can show signs of hyperactivity and agitation with death resulting by cardiorespiratory arrest or paralytic rabies, where muscles gradually become paralyzed with a coma slowly developing and eventual death; and (2) paralytic rabies, which runs a less dramatic and usually longer course than the furious form with the muscles gradually becoming paralyzed, then a coma slowly develops, and eventually death occurs. (World Health Organization 2013).

1.1.1.3.4 Raccoon Roundworm

Raccoon Roundworm, *Baylisascaris procyonis*, is an infection caused by the ingestion of roundworm eggs. The primary host for the roundworm is raccoon; however, other small mammals and birds can become infected. Dogs can also become infected by eating an infected animal, potentially passing worm eggs through their feces. Anyone who is exposed to areas where raccoons frequent is potentially at risk; however, children and the developmentally disabled are at higher risk as they are more likely to put soil and contaminated fingers and objects in their mouths (CDC 2012l). Larvae hatch in the intestines and migrate throughout the body affecting the brain and spinal cord, the eyes, and other organs (CDC 2012m). Tissue damage and symptoms tend to be severe due to the larval roundworm size, their ability to migrate throughout the body, and that they do not die readily (CDC 2012n).

1.1.2 Potential for Human and Animal Illness

To avoid or manage the risk to human and animal health from the diseases listed above requires effective vector-borne disease surveillance and control strategies that may fluctuate temporally and regionally. Such factors include mosquito and pathogen biology, environmental factors, land use patterns, and resource availability to support production of the vectors in quantities that threaten human and animal health. For example, detecting and monitoring WNV activity is accomplished by testing mosquitoes, dead birds, sentinel chickens, horses, and humans. The District identifies the mosquito species present, its locations and densities within the Service Area, and then the disease potential.

The District engages in activities and management practices to control mosquitoes and other vectors and to address the specific situations within its Service Area. These management practices emphasize the fundamentals of integrated pest management (IPM) wherein source reduction, habitat modification, and biological control are used when appropriate before resorting to pesticides. When pesticides are used, they are applied in a manner that minimizes risk to human health and ecological health.

1.1.3 Legislative and Regulatory Actions

A number of legislative and regulatory actions form the basis for the District's authority to engage in vector control. The District is a regulatory agency formed pursuant to California Health and Safety Code Section 2000 et seq. In enacting that law the California Legislature recognized the importance to public health and the economy of proactive management of pests. The Legislature thus found and declared Health and Safety Code, Section 2001:

1. California's climate and topography support a wide diversity of biological organisms.
2. Most of these organisms are beneficial, but some are vectors of human disease pathogens or directly cause other human diseases such as hypersensitivity, envenomization, and secondary infections.

3. Some of these diseases, such as mosquito-borne viral encephalitis, can be fatal, especially in children and older individuals.
4. California's connections to the wider national and international economies increase the transport of vectors and pathogens

The Legislature granted the District broad powers to address the threat to public health and the economy posed by vectors. State law charges the District with the authority and responsibility to take all necessary or proper steps for the control of mosquitoes and other vectors in the District and specified its duties as follows:

Pursuant to Sections 2040-2045, the District may conduct all of the following activities:

(a) Conduct surveillance programs and other appropriate studies of vectors and vector-borne diseases.

(b) Take any and all necessary or proper actions to prevent the occurrence of vectors and vector-borne diseases.

(c) Take any and all necessary or proper actions to abate or control vectors and vector-borne diseases.

(d) Purchase the supplies and materials, employ the personnel, and contract for the services that may be necessary or proper to carry out the purposes and intent of this chapter.

(e) Build, repair, and maintain on any land the dikes, levees, cuts, canals, or ditches that may be necessary or proper to carry out the purpose and intent of this chapter.

(f) Engage necessary personnel, to define their qualifications and duties, and to provide a schedule of compensation for the performance of their duties.

(g) Participate in, review, comment, and make recommendations regarding local, state, or federal land use planning and environmental quality processes, documents, permits, licenses, and entitlements for projects and their potential effects on the purposes and intent of this chapter.

(h) Contract with other public agencies and federal agencies to provide any service, project, or program authorized by this chapter within the district's boundaries. A district may contract with other public agencies to provide any service, project, or program authorized by this chapter within the boundaries of the other public agencies and federal agencies.

In accordance with California Health and Safety Code Section 2053:

(a) A district may request an inspection and abatement warrant pursuant to Title 13 (commencing with Section 1822.50) of Part 3 of the Code of Civil Procedure. A warrant issued pursuant to this section shall apply only to the exterior of places, dwellings, structures, and premises. The warrant shall state the geographic area which it covers and shall state its purposes. A warrant may authorize district employees to enter property only to do the following:

   (1) Inspect to determine the presence of vectors or public nuisances.

   (2) Abate public nuisances, either directly or by giving notice to the property owner to abate the public nuisance.

   (3) Determine if a notice to abate a public nuisance has been complied with.

   (4) Control vectors and treat property with appropriate physical, chemical, or biological control measures.

(b) Subject to the limitations of the United States Constitution and the California Constitution, employees of a district may enter any property, either within the district or property that is located outside the district from which vectors may enter the district, without hindrance or notice for any of the following purposes:

(1) Inspect the property to determine the presence of vectors or public nuisances.

(2) Abate public nuisances pursuant to this chapter, either directly or by giving notice to the property owner to abate the public nuisance.

(3) Determine if a notice to abate public nuisance has been complied with.

(4) Control vectors and treat property with appropriate physical, chemical, or biological control measures.

On September 20, 2014, Section 1506 of the Fish and Game Code, relating to wildlife management, was approved (known as AB 896, Eggman). It clarifies the intent of the Legislature to control mosquito production on managed wetland habitat owned or managed by CDFW and to increase coordination and communication between CDFW, local mosquito abatement and vector control districts, and CDPH.

1.1.3.1.1 Cooperative Agreement between the California Department of Public Health and Local Vector Control Agencies

Due to their public health mission, the California Department of Pesticide Regulation's (CDPR's) Pesticide Regulatory Program provides special procedures for vector control agencies that operate under a Cooperative Agreement with the CDPH. The application of pesticides by vector control agencies is regulated by a special and unique arrangement among the CDPH, CDPR, and County Agricultural Commissioners. CDPR does not directly regulate vector control agencies. CDPH provides regulatory oversight for vector control agencies that are signatory to the Cooperative Agreement. Signatories to the agreement use only pesticides listed by CDPH, maintain pesticide use reports, and ensure that pesticide use does not result in harmful residues on agricultural products.

The District maintains a cooperative agreement with CDPH (CDPH and MSMVCD 2014). Its employees are certified by CDPH as vector control technicians, which help to ensure that employees are adequately trained regarding safe and proper vector control techniques including the handling and use of pesticides and compliance with laws and regulations relating to vector control and environmental protection.

In 2015, CDFW determined that CDPH, and the districts operating under a valid Cooperative Agreement with CDPH to conduct surveillance, prevention, or control of vectors and vector-borne diseases, are not required to obtain a scientific collections permit (SCP) under Fish and Game Codes Sections 1002, 4005(e), and 4011. A SCP is required for any scientific study conducted by or in collaboration with CDPH or local agencies, which is not routine surveillance and control activities and includes take of animals or plants. (CDFW 2015)

1.1.3.1.2 California Pesticide Regulatory Program

CDPR regulates the sale and use of pesticides in California. CDPR is responsible for reviewing the toxic effects of pesticide formulations and determining whether a pesticide is suitable for use in California through a registration process. Although CDPR cannot require manufacturers to make changes in labels, it can refuse to register products in California unless manufacturers address unmitigated hazards by amending the pesticide label. Consequently, many pesticide labels that are already approved by the United States Environmental Protection Agency (USEPA) also contain California-specific requirements. Pesticide labels defining the registered applications and uses of a chemical are mandated by USEPA as a condition of registration. The label includes instructions telling users how to make sure the product is applied only to intended target pests, and includes precautions the applicator should take to protect

human health and the environment. For example, product labels may contain such measures as restrictions in certain land uses and weather (i.e., wind speed) parameters.

1.2 Program Objectives/Purpose and Need

1.2.1 Program Objectives

The District undertakes vector control activities through its Program to control the following vectors of disease and/ or discomfort in the Program Area: mosquitoes, cockroaches, fleas, flies, rats, mice, ticks, yellow jacket wasps, and other stinging/biting insects (including mites and bed bugs). The District may control noxious/invasive weeds primarily to facilitate access to vector habitat and as a vector habitat source reduction measure.

The Proposed Program's specific objectives are as follows:

> Reduce the potential for human and animal disease caused by vectors

> Reduce the potential for human and animal discomfort or injury from vectors

> Accomplish effective and environmentally sound vector management by means of:

- Surveying for vector presence, abundance, distribution, human and animal contact or potential for human and animal contact
- Establishing treatment guidelines
- Appropriately selecting from a wide range of Program tools or components

Most of the relevant vectors are quite mobile and cause the greatest hazard or discomfort at a distance from where they breed. Each potential vector has a unique life cycle, and most of them occupy several types of habitats. To effectively control them, an IVMP must be employed. District policy is to identify those species that are currently vectors, to recommend techniques for their prevention and control, and to anticipate and minimize any new interactions between vectors and humans through direct control or through advice to property owners and the public.

1.2.2 Purpose and Need

The District was established in 1915 to reduce the risk of vector-borne disease and discomfort to the residents of its Service Area. In addition to being nuisances by disrupting human activities and enjoyment of public and private areas, certain vectors can transmit a number of diseases. A vector is defined by the State of California as "any animal capable of transmitting the causative agent of human disease or capable of producing human discomfort or injury, including, but not limited to, mosquitoes, flies, other insects, ticks, mites, and rats, but not including any domesticated animal…" [California Health and Safety Code Section 2200(f)]. The diseases of most concern in the Program Area are as follows, by the vector they are associated with:

> Mosquito-transmitted illnesses: WNV, WEE, SLE, dog heartworm, malaria, and myxomatosis

> Tick-transmitted illnesses: Lyme disease, babesiosis, ehrlichiosis, tularemia, spotted fever group *Rickettsia*, *Rickettsia 364D,* anaplasmosis

> Rodent/rat-transmitted illnesses: leptospirosis, hanta virus pulmonary syndrome (HPS), tularemia, plague

> Other vector-transmitted illnesses: rabies transmitted by skunks, plague and murine typhus transmitted by fleas (usually on rats), raccoon roundworm

Depending on the disease, both human and domestic animal health can be at risk of disability, illness, and/or death. Furthermore, potential exists for introduction and transmission of new diseases by current

vectors and for new disease vectors to be introduced into the District's Service Area. An example of this is the recent discovery of *Aedes albopictus* (i.e., Asian tiger mosquito) and *Aedes aegypti* (i.e., yellow fever mosquito) mosquitoes in central and southern California. These mosquito species are known to be vectors of diseases such as Chickungunya virus, yellow fever, and Dengue fever.

1.3 Alternatives Considered in this Programmatic Environmental Impact Report

The District's Program is an ongoing series of related actions for control of mosquitoes and other vector populations to minimize human vector interactions and the associated risks of disease and discomfort. The District's activities involve the identification of vector problems; proactive and responsive actions to control existing populations of vectors, prevention of new sources of vectors from developing, and management of habitat to minimize vector production; education of landowners and others on measures to minimize vector production or interaction with vectors; and provision and administration of funding and institutional support necessary to accomplish District objectives.

For at least the past two decades, the District has taken an integrated systems approach to mosquito and vector control utilizing a suite of tools that consist of:

> Surveillance

> Physical Control

> Vegetation Management

> Biological Control

> Chemical Controls
  - Larvicides
  - Adulticides
  - Other

> Other Nonchemical Control/Trapping

> Public Education

These first six tools are called "alternatives," are part of the present Program, and all would continue and be combined as the overall Proposed Program along with public education. These alternative Program "tools" or components within the Proposed Program are described in the subsequent subsection as "Program alternatives" for the CEQA environmental impact analysis process (except for public education, which is exempt from CEQA). Alternatives to the overall Proposed Program as required under CEQA are presented in Section 15.4. Program implementation is weighted heavily towards vegetation management and physical and biological controls, in part, to reduce the potential for environmental impacts. To realize effective and environmentally sound vector management, vector control must be based on several factors:

> Carefully monitoring or surveying vector abundance and/or potential contact with people

> Carefully monitoring and surveying for vector-borne diseases and their antecedent factors that initiate and/or amplify disease

> Establishing treatment guidelines

> Selecting appropriate tools from a wide range of control methods

This Program consists of a dynamic combination of surveillance, treatment guidelines, and use of multiple control activities in a coordinated program with public education that is generally known as integrated pest management (IPM) or specifically for the District as Integrated Vector Management (IVM) when focused on vector control.

The District's IVMP, like any IPM program, seeks by definition to use procedures that will minimize potential environmental impacts. The District's IVMP employs IPM principles by first identifying the species and abundance of mosquitoes/vectors through evaluation of public service requests and field surveys of immature and adult mosquito/vector populations and, then, if the populations exceed treatment guidelines, using the most efficient, effective, and environmentally sensitive means of control. For all mosquito species, public education is an important control strategy. In some situations, water management or other physical control activities can be instituted to reduce mosquito-breeding sites. The District also uses biological control such as the planting of mosquitofish in some settings including: ornamental fish ponds, water troughs, water gardens, fountains, and unmaintained swimming pools. When these approaches are in their initial phases, not effective, or are otherwise deemed inappropriate, then pesticides are used to treat specific vector-producing or vector-harboring areas.

Three core tenets are essential to the success of a sound IVMP.

> *First*, a proactive approach is necessary to minimize impacts and maximize successful vector management. Elements such as thorough surveillance and a strong public education program make all the difference in reducing potential human vector interactions.

> *Second*, long-term environmentally based solutions (e.g., water management, reduction of harborage and food resources, exclusion, and enhancement of predators and parasites) are optimal as they reduce the potential pesticide load in the environment as well as other potential long- and short-term impacts.

> *Lastly*, utilizing the full array of options and tools (public education, surveillance, physical control, biological control, and when necessary chemical control) in an informed and coordinated approach supports the overall goal of an environmentally sensitive vector management program.

The No Program Alternative is defined as the District not engaging in any of the control strategies and tools for mosquito and/or vector control. Past practices would not continue into the future. The District would not continue to operate and would close. In the absence of the District, CDPH would need to provide mosquito and vector "oversight" to local jurisdictions commensurate with their budget constraints. See Section 15.3.

1.4 Public Involvement

Public involvement for this PEIR includes the following actions.

1.4.1 CEQA Public Scoping

Marin/Sonoma Mosquito and Vector Control District (District) distributed a Notice of Preparation (NOP) of a Draft PEIR for the Integrated Mosquito Management Program (Program) pursuant to CEQA Guidelines (Section 15082) on May 25, 2012. The NOP was sent to 353 agencies, organizations, and individuals, including these California responsible and trustee agencies:

> Air Resources Board

> Cal-EPA

> Caltrans District 4

> Coastal Commission

> Coastal Conservancy

> Department of Boating and Waterways

> Department of Fish and Wildlife, Region 3

> Department of Food and Agriculture

> Department of Parks and Recreation
> Department of Pesticide Regulation
> Department of Public Health
> Department of Public Health/Drinking Water
> Department of Toxic Substances Control
> Department of Water Resources
> Division of Forestry
> Native American Heritage Commission
> San Francisco Regional Water Quality Control Board (SFBRWQCB)
> State Lands Commission
> State Water Resources Control Board (SWRCB)

The NOP provided a description of the Program, the location of Program activities, and the resources and environmental concerns planned for analysis in the PEIR. The NOP announced public scoping meetings and requested the comments on the content of the PEIR and the Program alternatives be submitted within 30 days of receipt. Two public scoping meetings were held at the following locations and times:

> San Rafael Community Center in San Rafael on June 12, 2012, at 7:00 pm.
> Rohnert Park Senior Center in Rohnert Park on June 14, 2012, at 7:00 pm.

1.4.2 Public Scoping for Programmatic Environmental Impact Report

Public scoping resulted in the following comments that are focused on additional public notification during Program implementation.

> Notify Department of Public Works Marin County of all activities occurring on the public lands and/or easements, including surveillance, source reduction, biological and chemical control, and any other activities.
> Describe and evaluate the effectiveness of procedures for notifying the public and nearby property owners about the intent to use aerial treatment.
> Public knowledge over the treatment process: should be discussion in the media concerning the actions being taken in the District.
> Use of sovereign lands controlled by California State Lands Commission requires the District to obtain lease agreement.
> Concern that title holders of foreclosed/neglected properties that provided habitat for mosquitoes have not paid a fine.

Comments for the PEIR are addressed under Section 1.5 below, Section 2.4, Public Education, and Section 2.8.2, Agency Coordination.

1.4.3 Areas of Known Public Concern

CEQA Guidelines Section 15123 requires that the Summary “shall identify areas of controversy known to the lead agency.” The areas of greatest public concern and debate are based on comments from public scoping and comments made during other District activities. These areas of controversy are explained here and incorporated into the preceding Summary chapter:

> Use of Pesticides for Vector Control: Members of the public are distrustful of pesticide use for vector control. They prefer other methods to eliminate suitable habitat to deal with mosquito problem rather than using pesticides. If adulticides must be used, ensure use is justified with documented, mosquito-borne disease activity within or within flight range of the tidal marsh (mosquito source). Concern exists about pesticide applications drifting into backyards where the property owner wants to ensure their area is pesticide-free. The concern is not only with impacts to humans and "sensitive populations" but also to domestic animals and wildlife including nontarget insects.

> Use of Herbicides for Vegetation Management: Request for specific vegetation management information about the proposed chemical vegetation control agents (herbicides), the types, amounts and locations of chemical stored, application methods and rates, and their effects on the environment.

> Use of Biological Control Agents: Controversy exists over the use of some proposed biological control agents, in particular the use of mosquitofish and potential for them to impact special-status species such as the California red-legged frog.

> District's Authority to Enter Public and Private Property for Control Activities: Some public agencies want the District to obtain an Encroachment Permit with notification of Park Supervisors for activities such as surveillance, physical control, or vegetation management where access to parkland is needed. Water districts insist that mosquito abatement materials and practices proposed for use on watershed lands must be thoroughly vetted and approved by CDPH. New legislation in 2014 clarified responsibilities of CDFW and the District to engage in mosquito abatement in CDFW owned and/or managed wildlife refuges.

Section 1.5, Environmental Concerns, presents a summary of the environmental concerns by resource or issue area for analysis in the PEIR.

1.4.4 Distribution of the Programmatic Environmental Impact Report

The District has distributed the Notice of Availability of the Draft PEIR to the following agencies, organizations, and individuals.

CEQA Clearinghouse

ABAG Clearinghouse
State Clearinghouse

Federal Agencies

Golden Gate National Recreation Area
Gulf of Farallones NMFS
National Marine Fisheries Service-NOAA
Point Reyes National Seashore
US Army Corps of Engineers
US Fish & Wildlife Service
USDA Natural Resources Conservation

State Agencies

BAAQMD
CA Air Resources Board
CA Coastal Commission
CA Coastal Conservancy
CA Dept. of Boating and Waterways
CA Dept. of Fish & Game, Reg. 3
CA Dept. of Food & Agriculture
CA Dept. of Parks & Recreation
CA Dept. of Pesticide Regulation
CA Dept. of Public Health
CA Dept. of Public Health/Drinking Water
CA Dept. of Toxic Substances Control
CA Dept. of Water Resources
CA EPA
CA Native American Heritage Commission
CA Parks & Recreation Resource Protection Division
CA Regional Water Quality Control Board
CA State Lands Commission
CA State Water Resources Control Board
California Division of Forestry
Caltrans District 4
Dept. Food/Ag Milk/Dairy Control Branch
SF Bay Conservation & Development Comm.
US Geological Survey

Local Government

Camp Meeker Rec Park District
City of Belvedere
City of Belvedere Planning Department
City of Larkspur
City of Larkspur Planning Department
City of Mill Valley
City of Mill Valley Planning Department
City of Novato
City of Novato Planning Department
City of Petaluma
City of Petaluma Planning Department
City of San Anselmo Planning Department
City of San Rafael
City of San Rafael Planning Department
City of Sausalito
City of Sausalito Comm. Dev.
Community Development Agency Staff
Cotati City Planning Department
Gold Ridge Resource Conservation District
Healdsburg City Planning Department
Lake County Planning Department
Marin Resource Conservation District
Monte Rio Rec & Park District
Northern Sonoma County Air Pollution Control District
Petaluma City Planning Department
Petaluma-Adobe State Historical Park
Rohnert Park Planning Department
Santa Rosa City Planning Department
Santa Rosa Community Development Agency
Sebastopol City Planning Department
Sonoma City Planning Department
Sonoma Co Permit & Resource Management
Sonoma County Agriculture Preservation and Open Space District
Sonoma County Health Services
Town of Corte Madera
Town of Corte Madera Planning Dept.
Town of Fairfax
Town of Fairfax Planning Dept.
Town of Ross
Town of Ross Planning Dept.
Town of Tiburon
Town of Tiburon Planning Dept.
Town of Windsor

School Districts

Alexander Valley Union School District
Bellevue Union School District
Bennett Valley Union School District
Bolinas-Stinson Union School District
Calistoga Join unified School District
Cazadero Water Co.
Cinnabar School District
City of Sausalito Marin
City School District
Cloverdale Planning Department
Cloverdale School District
Corte Madera Larkspur School District
Cotati-Rohnert Park School District
Dixie School District
Dominican University
Dunham School District
Forestville Union School District
Fort Ross School District
Geyserville School District
Gravenstein Union School District
Guerneville School District
Harmony Union School District
Healdsburg School District
Healdsburg Water District
Horicon School District
Kashia School District
Kentfield School Dist.
Kenwood School District
Laguna Joint School and District
Lagunitas School District
Liberty School District
Lincoln School and District
Mark West Union School District
Mill Valley School District
Monte Rio Union School District
Montgomery School District
Nicasio School District
Novato Unified School District
Oak Grove Union School District
Old Adobe Union School District
Petaluma City School District
Piner-Olivet Union School District

Reed Union School District
Rincon Valley Union School District
Roseland School District
Ross School District
Ross Valley School District
San Rafael City Schools
San Rafael High School District
San Rafael School District
Santa Rosa City School District
Sebastopol School
Shoreline Unified School District
Shoreline Unified School District
Sonoma Valley School District
Tam Union High School Dist.
Twin Hills Union School District
Two Rock Union School District
Waugh School District
West Side Union School District
West Sonoma County High School District
Wilmar Union School District
Windsor School District
Windsor Unified School District
Wright School District

Service Districts

Alexander Valley Water District
Almonte Sanitary District
Alto Sanitary District
Bel Marin Keys CSD
Bodega Bay Public Utility District
Bolinas Community Public Utility District
Cazadero Community Services District
Central Marin Sanitation Agency
Citizens Utilities
Cloverdale Water District
Corte Madera Sanitary District #2
Cotati City Water District
County Service Area #31
Fitch Mountain Water District
Flood Control 7 Adv. Board
Forestville Water Co.
Geyserville Water
Hacienda Water Co.
Homestead Valley Sanitary District
Inverness Public Utility District
Jenner Water Co.
Kenwood/Penngrove Water
Las Gallinas Sanitary District
Marin City Community Service District
Marinwood Community Service District
Muir Beach Community Service District
North Coast Regional Water Quality Control Board
Novato Sanitary District
Occidental Comm. Services District
Occidental Water Co.
Palomino Lakes Mutual Water
Petaluma City Water District
Rancho Del Paradiso Water Co.
Redwood Valley Water District
Richardson Bay Sanitary District
Ross Valley Sanitary District #1
Russian River Water
San Rafael Sanitary District
Santa Rosa Water District
Sausalito-Marin City Sanitary Dist.
Sea Ranch Village Inc.
Sea Ranch Water Co.
Sebastopol Water District
Sereno Del Mar Water Company
Sewage Agency of Southern Marin
Sonoma City Water Department
Sonoma County Water Agency
Sotoyome Heights Water Co.
Sotoyome Resource Conservation District
Southern Sonoma County Resource Conservation District
State Parks – Russian River District OFC
Stinson Beach Water Dist.
Tam Community Service District
Tiburon Sanitary District #5
Timber Cove Water
Tomales Village Community Service District
Valley of the Moon Water District
Willowside Mutual Water Co.

Transportation

California Northern Railroad Company
Golden Gate Bridge District
North Coast Railroad Authority

North Western Pacific Railroad
Sonoma-Marin Area Rail Transit

Union Pacific Railroad Company

1.5 Environmental Concerns

Below is a listing of environmental concerns by resource (i.e., by PEIR section), including but not limited to issues raised by agencies and the public. These concerns are those most appropriate to the environmental impact analysis rather than questions concerning Program implementation or future coordination activities between the District and other agencies and individuals. Additional environmental concerns can be addressed through responses to public comments on the Draft PEIR.

1.5.1 Urban and Rural Land Uses

The following concerns are associated with land uses, both urban/developed lands and rural/open space/undeveloped lands. They are addressed primarily in Chapter 3, *Urban and Rural Land Uses*:

> Need to analyze and minimize aspects of the Program that diminish recreational experience of park visitors of the regional parks and trails within the Program Area.

> Expressed concern with impacts at school sites.

> Address local community regulations regarding pesticides.

1.5.2 Biological Resources-Aquatic

The following concerns are associated with biological resources in aquatic environments and are addressed in Chapter 4 of this PEIR or in Appendix A, *Biological Resources Technical Report*:

> Employ techniques associated with the physical control of vectors and their habitat that conform to Habitat Conservation Plan (HCP) avoidance, minimization, and mitigation measures.

> Ensure mosquito abatement staff minimize impact to tidal marsh habitats (especially during breeding season).

> The PEIR should include a detailed description and complete assessment of the surveillance impacts (current and future, direct and indirect) on habitats (including endangered, threatened, and locally unique species and sensitive habitats) and on species (sensitive fish, wildlife, or plants)

> The PEIR should include a detailed description and complete assessment of the biological control impacts (current and future, direct and indirect) on habitats (including endangered, threatened, and locally unique species and sensitive habitats) and on species (sensitive fish, wildlife, or plants).

> The PEIR should include a detailed description and complete assessment of the chemical control impacts (current and future, direct and indirect) on habitats (including endangered, threatened, and locally unique species and sensitive habitats) and on species (sensitive fish, wildlife, or plants). This issue is also addressed in Section 6.2.

1.5.3 Biological Resources-Terrestrial

The following concerns are associated with biological resources in terrestrial environments and are addressed in Chapter 5 of this PEIR or in Appendix A, *Biological Resources Technical Report*:

> Discuss potential impacts on insect pollinators/bees from chemicals in treatment applications.

> Describe the effects of all chemicals that are used and/or proposed for use on wildlife and natural ecosystems, including insect prey, birds, mammals, fish, vegetation and site topography. The loss of prey for birds is a particular concern. Also, consider unwanted effects of the “inactive” portion of the pesticides. What effects will the carrier portion of the chemicals have on the environment?

> Discuss the potential impact of Bs/Bti products on native species.

> Describe the role of mosquitoes within the food chain, and subsequent impacts if they were removed in terms of amphibians, birds, reptiles, fish and insects. This issue is also addressed in Section 6.2.

> Pesticides can also kill the natural predators of mosquitoes, which have great difficulty in recovery from pesticides.

> Pesticide efficacy attenuation and possible long-term resistance is an issue for all chemically based mosquito control programs. It is addressed by the use of different control methods and different agents over time where possible (BMP and IVM techniques are designed to identify these issues early and modify applications as appropriate and feasible.

> Note that the Program Area includes potential habitat for several California and federally threatened and other sensitive plant and wildlife species and, as such, comprehensive biological studies should be implemented.

> Coordinate with CDFW, California Natural Diversity Database (CNDDB), USFWS, and USFWS' Information, Planning, and Conservation planning tool to identify special-status plant and wildlife species. If impacts are found to be significant, the PEIR should identify adequate mitigation measure to reduce impacts to lower levels.

> A primary concern is the environmental impact on natural resources in terms of vegetation removal, soil erosion, and possible wildlife impact.

> Ensure mosquito abatement staff minimizes impact to tidal marsh and vernal pool habitats (especially during breeding season). Restrict operation of vehicles to levees and existing roads, and avoid vernal pool plants during blooming season (March–June).

> Concern for spread of invasive weeds, erosion, and sedimentation.

> The PEIR should include a detailed description and complete assessment of the surveillance, physical control, biological control, and chemical control impacts (current and future, direct and indirect) on habitats (including endangered, threatened, and locally unique species and sensitive habitats) and on species (sensitive fish, wildlife, or plants).

1.5.4 Ecological Health Hazards

The following concerns are associated with ecological health and are addressed in Chapter 6 of this PEIR or in Appendix B, *Ecological and Human Health Assessment Report*:

> What are the impacts associated with the Surveillance Alternative?

> Describe the effects of all chemicals that are used and/or proposed for use on wildlife and natural ecosystems, including insect prey, birds, mammals, fish, vegetation, and site topography. The loss of prey for birds is a particular concern.

> Discuss the potential impact of *Bacillus sphaericus* (Bs is a bacterium whose spores can persist in the environment for several weeks to months) on native species. What would justify its use? What native species would be impacted?

> Discuss impacts on bees from chemicals in treatment applications.

> Concern over the "inactive" portion of the pesticides. What effects will the carrier portion of the chemicals have on the environment?

> Discuss the effects of pesticides on the natural predators of mosquitoes.

> The continued spray program leads to survival of mosquitoes resistant to pesticides – "the pest mill."

> Describe the role of mosquitoes within the food chain, and subsequent impacts if they were removed in terms of amphibians, birds, reptiles, fish, and insects.

> Upon application and broadcast of pesticides, what is the fate and transport of these chemicals? Look at droplet size, dispersal patterns given wind, conversion products (both in storage and environment), and impacts of conversion products. Discuss the persistence of proposed treatment substances in the environment as well as the potential for bioaccumulation.

> The PEIR should include monitoring programs that are designed to validate assumptions regarding the environmental fate and transport of materials.

> The PEIR should include a detailed description and complete assessment of the chemical control impacts (current and future, direct and indirect) on habitats (including endangered, threatened, and locally unique species and sensitive habitats) and on species (sensitive fish, wildlife, or plants) and ensure CEQA requirements are met.

> The PEIR should include a detailed description and complete assessment of the biological control impacts (current and future, direct and indirect) on habitats (including endangered, threatened, and locally unique species and sensitive habitats) and on species (sensitive fish, wildlife, or plants) and ensure CEQA requirements are met.

1.5.5 Human Health Hazards

The following concerns are associated with human health and are addressed in Chapter 7 of the PEIR or in Appendix B, *Ecological and Human Health Assessment Report*.

> The PEIR should address Program impacts on people and pets through ingestion and absorption pathways and proposed mitigation. Address impacts on chemically sensitive people and sensitive populations such as children, the elderly, and pregnant women. Exposure to pesticides can result in compromised immune system, which would allow for development of allergies or autoimmune disorders.

> The PEIR must list any and all biological or chemical agents proposed for use.

> CDPH should be consulted to ensure all potential risks are identified, characterized, and evaluated.

> Concern expressed over public safety and health with regard to existing vegetable gardens and fruit trees within the Program Area. Local swimming holes could be a potential habitat for breeding mosquitoes, and chemical treatment could impact humans.

> Concerned with use of Zenivex®; it mimics chrysanthemums but is a harmful neurotoxin.

> Concerned that adulticides may present danger to humans, as many are known carcinogens and endocrine disruptors.

> Concerned that pyrethrins may disrupt the normal functioning of sex hormones, while piperonyl butoxide (PBO) may affect the functioning of hormone-related organs.

> How long are pesticides retained in humans (young infant through elderly), pets, home garden vegetables and fruit, etc.?

> In addition to short-term effects, what are the long-term effects of repeated exposure to these chemicals?

1.5.6 Public Services and Hazard Response

While no scoping comments directly dealt with public services and hazard responses, the following issues are addressed in Chapter 8 of the PEIR:

> Risk of spill of hazardous materials from equipment/vehicles or applications of pesticides and/or herbicides.

> Risk of aerial equipment failure during applications of pesticides.

> Safe storage and disposal of chemical-related materials including pesticide containers.

1.5.7 Water Quality

Chapter 9, *Water Resources*, addresses concerns related to the following potential impacts to surface water and groundwater resources:

> Consideration of CDPH review and approval of mosquito abatement materials and practices proposed for use on watershed lands.

> Integration of "Source Reduction" strategies with Stream Maintenance Program approaches in Water Agency-owned flood control channels. (Sonoma County Water Agency)

> Need for description and quantification of dredge or fill activities and evaluation of their impacts.

> Impacts of drift from aerial and ground applications on waterbodies, watersheds, and drinking water supplies.

> Concern for spread of invasive weeds, erosion and sedimentation.

> Concern about the use of mosquito larvicides and adulticides in or associated with septic tank (onsite wastewater treatment systems) and the potential to impact surface or groundwater resources.

1.5.8 Air Quality and Climate Change

The following environmental concerns are addressed in Chapter 10, *Air Quality*, and Chapter 11, *Greenhouse Gases and Climate Change*, in this PEIR and in Appendix C, *Air Quality and GHG Technical Report*:

> Address spraying/fogging effects on air quality for humans and pets alike.

> Address impacts of emissions of air pollutants from control and treatment methods and combustion of fuels.

> Address impacts on greenhouse gas emissions and climate change.

1.5.9 Noise

The following environmental concerns are addressed primarily in Chapter 11, *Noise*, in this PEIR and in Appendix D, *Noise Technical Report*:

> Evaluate noise-related impacts on humans, in particular consistency with local noise regulations.

> Evaluate noise-related impacts on wildlife.

Impacts of Program noise on wildlife are addressed in Chapter 5, *Biological Resources-Terrestrial*.

1.6 Impacts Not Given in-Depth Evaluation in this Programmatic Environmental Impact Report

The Proposed Program's surveillance, physical control, vegetation management, biological control, and chemical and nonchemical treatment alternatives were determined to have no impacts or less-than-significant impacts on the resources listed below; therefore, further analysis of these resources was not necessary for the reasons identified below. The resources not considered thereafter in the PEIR, or those partially considered (and how they are considered), include:

> Aesthetics. In general the implementation of the vector control strategies and methods would not impact the aesthetics of the Program Area. No new construction of facilities would occur, the application of materials from the ground or the air would not have a visual impact because the Program alternatives are too small in scale to be noticeable in the open areas, and they would blend in with the habitat where they would be applied, including physical control and vegetation removal for mosquito control. None of the materials to be applied would change the appearance of existing structures or visual features of the landscape. The applied materials would not harm painted surfaces of structures, signs, and roadways.

> Cultural Resources. The activities associated with vector control would not include any construction of facilities or subsurface ground disturbance beyond drainage control, including sediment and vegetation removal to improve water circulation in aquatic habitats. Material application would not occur on existing historical resources; therefore, cultural resources would not be impacted. However, if during the application of material in either developed or undeveloped areas human remains are encountered, the applicable county coroner would be contacted and appropriate measures implemented, consistent with State Health and Safety Code Section 7050.5, which prohibits unauthorized disinterring, disturbing, or removing of human remains from any location.

> Geology and Soils. The activities associated with mosquito and/or vector control would not include any facilities construction or significant ground disturbance nor induce erosion or loss of topsoil; therefore, geology and soils would not be impacted in this manner. Program activities would not be affected by landslides or ground failure, because aerial application would be used primarily in open-space areas if needed. The issue of impacts to soil microbes is addressed in the fate and transport analysis of the chemical treatments.

> Mineral Resources. The activities associated with mosquito and/or vector control would not include any new construction or alteration of subsurface resources beyond drainage control; therefore, the Program would not result in the loss of availability of a known mineral resource.

> Population and Housing. The Program would not add new housing or increase the resident population within the Program Area; therefore, the Program is not expected to impact population and housing growth. Because the Program would not result in new development, it would not place a substantial demand on most public services including public facilities. However, the Program's potential to impact public health and emergency response services is addressed in Chapter 8, *Public Services and Hazard Response*.

> Transportation and Traffic. The Program would not include the use of a substantial amount of new vehicles or block existing roadways for mosquito and/or vector control efforts. Light truck and automobile trips would be required to transport workers, materials, and equipment for the surveillance, monitoring, and physical control activities, and ground and aerial applications of pesticides and/or herbicides. These trips would be consistent with present trips and not result in a substantial change in vehicle use over existing conditions. Therefore, no impacts would be associated with Program transportation or traffic.

> Utilities and Service Systems. The Program would not include any new construction or the addition of housing or new workers to a community that would result in a substantial increase in demand for new utilities and service systems. Therefore, the Program is not expected to impact the utilities, including electricity, cable, water, and wastewater, in the Program Area. Water resources are addressed in Chapter 9, *Water Resources*.

1.7 Report Organization and Significance Terminology

The PEIR evaluates potential environmental impacts (direct, indirect, and cumulative) on the following environmental resources and concerns: human health, ecological health, agricultural economics and land use, nonagricultural land uses, public services/hazard response, water quality (surface water and groundwater), air quality, climate change (greenhouse gas production), noise, and biological resources, including cumulative impacts. The human and ecological risk assessments are technical appendices to the PEIR with important results summarized in the appropriate sections of the PEIR.

> Chapter 1, Introduction, provides the Program's history and authority, Program objectives, a summary of public involvement activity and the public's concerns, impacts not further evaluated, and the PEIR's organization.

> Chapter 2, Program Description, presents the Program objectives, chemical treatment and nonchemical treatment alternatives, and best management practices (BMPs) to minimize environmental impacts. It also describes equipment use, public education, and required permits and agency coordination.

> Chapter 3, Urban and Rural Land Uses, explains the environmental setting and potential environmental impacts for each alternative.

> Chapter 4, Biological Resources – Aquatic, explains the environmental setting and potential environmental impacts for each alternative.

> Chapter 5, Biological Resources – Terrestrial, explains the environmental setting and potential environmental impacts for each alternative.

> Chapter 6, Ecological Health, explains the environmental setting and potential environmental impacts for each alternative.

> Chapter 7, Human Health, explains the environmental setting and potential environmental impacts for each alternative.

> Chapter 8, Public Services and Hazard Response, explains the environmental setting and potential environmental impacts for each alternative.

> Chapter 9, Water Resources, explains the environmental setting and potential environmental impacts for each alternative.

> Chapter 10, Air Quality, explains the environmental setting and potential environmental impacts for each alternative.

> Chapter 11, Greenhouse Gases and Climate Change, explains the environmental setting and potential environmental impacts for each alternative.

> Chapter 12, Noise, explains the environmental setting and potential environmental impacts for each alternative.

> Chapter 13, Cumulative Impacts, is a comprehensive assessment of all of the potential cumulative impacts to each of the resources contained in Chapters 3 through 12.

> Chapter 14, Other Required Disclosures, is comprised of other analyses required by CEQA including growth-inducing impacts and irreversible or irretrievable commitments of resources.

> Chapter 15, Alternatives, presents the District's consideration of a reasonable range of alternatives and the screening of those alternatives to the ones included in the Proposed Program. It evaluates the No Program Alternative for impacts, and identifies two alternative programs: Reduced Chemical Control Alternative Program and No Chemical Control Alternative Program. for reducing potentially significant impacts from the Chemical Control Alternative under the Proposed Program.

> Chapter 16, Report Preparers, lists the persons and organizations involved in the preparation of this PEIR.

> Chapter 17, References, identifies the organizations and persons consulted and references cited in this PEIR.

> Appendix A, *Biological Resources Technical Report*

> Appendix B, *Ecological and Human Health Assessment Report*

> Appendix C, *Air Quality and Greenhouse Gas Emissions Technical Report*

> Appendix D, *Noise Analysis Technical Report*

> Appendix E, *Alternatives Analysis*

> Appendix F, *Supplemental IVMP Information*

For each resource evaluated, the key environmental issues and criteria, for determining whether an adverse impact is significant under CEQA, are discussed first. A "significant impact" is defined as:

> *"a substantial, or potentially substantial, adverse change in any of the physical conditions within the area affected by the project including land, air, water, minerals, flora, fauna, ambient noise, and objects of historic or aesthetic significance. An economic or social change by itself shall not be considered a significant effect on the environment, but may be considered in determining whether the physical change is significant"* (CEQA Guidelines Section 15382).

The environmental impact analysis section for each resource defines the criteria used to judge whether an impact is significant. These criteria include the "Mandatory Findings of Significance" set forth in CEQA Guidelines Section 15065. These criteria also include the criteria set forth in the Initial Study checklist (CEQA Guidelines, Appendix G), agency regulatory standards, or other criteria relevant to the specific project.

In describing the significance of adverse impacts, **the following categories of significance** are applied, based on the best professional judgment of the PEIR preparers:

> **Significant and Unavoidable (SU):** An impact that cannot be avoided or reduced to below the threshold level, even with the imposition of all feasible mitigation measures. "Significant" also covers the concept of potentially significant, which may be used when substantial uncertainty exists. This PEIR does not distinguish between "significant" or "potentially significant" in impact conclusion statements; both result in a determination that the impact is significant. All significant impacts from No Program are unavoidable.

> **Potentially Significant but Mitigable (SM):** An impact that can be reduced to below the threshold level (i.e., to less than significant) given feasible mitigation measures. For example, the statement is made that the impact to surface water resources from permethrin is potentially significant but mitigable. With the application of a mitigation measure to avoid application of permethrin in locations where the receiving waters are 303(d) listed for pyrethroids or sediment toxicity, the impact can be reduced to less than significant.

> **Less than Significant (LS):** An impact that may be adverse but does not exceed the threshold levels or covers an effect that is small or minimal, and does not require mitigation measures.

> **No Impact (N):** Where an impact is neutral or is clearly deemed "no effect," it is stated to have "no impact."

Mitigation measures for one resource may have environmental impacts on other resources or not be sufficient to reduce the target impact to less than significant. Where a mitigation measure could have a significant environmental impact, this impact is discussed.

1.8 Use of This PEIR for Future CEQA Compliance

This PEIR evaluates the potential environmental impacts associated with the District's current Program and its future Program when the activities and materials can be identified at present. For activities and materials not within the current Program that could be proposed at a future date to be included in the District's IVMP ("future activities"), the District will evaluate whether the proposed action or material was within the scope of the Program evaluated within the PEIR and whether additional environmental documentation is required. In making this determination, the District will first determine whether the activity would result in environmental effects that were not considered in the PEIR. If the subsequent activity involved site-specific operations, the District will evaluate the site and the activity to determine whether the environmental effects were covered in the PEIR and document its findings. Second, the District will evaluate the proposed activity or material to determine whether any new environmental effects could occur, or new mitigation measures would be required, due to changes in the activity or changes in the circumstances under which it is undertaken. If the District determines that the future activity is within the scope of the Program examined in the PEIR that no new effects that were not examined in the PEIR could occur, and that no new information shows that new mitigation measures or alternatives are required, the District may approve the activity as being within the scope of the PEIR, and no new environmental documentation is required. (CEQA Guidelines Section 15168(c)(1)-(2))

If the District determines that the future activity was not within the scope of the Program evaluated in the PEIR, the action will be considered a "new action." The District will determine whether the new action would result in environmental effects that were not examined in the PEIR by preparing an initial study. The initial study will be the basis for determining whether the effects of the new action require an EIR or a negative declaration. (CEQA Guidelines Section 15168(c)(1). A subsequent or supplemental EIR could be required if any of the following occur (CEQA Guidelines Section 15162[c]):

> Substantial changes proposed for the District's IVMP would require major revisions to this PEIR because of new significant environmental impacts that cannot be mitigated below a level of significance or a substantial increase in the severity of the previously identified significant impacts in this PEIR.

> Substantial changes to the circumstances under which the District's IVMP is undertaken would require major revisions to this PEIR because of new significant environmental impacts that could not be mitigated below a level of significance or a substantial increase in the severity of the identified significant impacts in this PEIR.

> New information of substantial importance that could not have been known at the time the PEIR was certified shows significant effects not discussed in this PEIR that cannot be mitigated below a level of significance; significant effects would be substantially more severe; mitigation measures found to be infeasible in this PEIR would, in fact, be feasible and substantially reduce one of more significant effects, but the District decides not to adopt them; or mitigation measures or alternatives are identified that are considerably different from those analyzed in this PEIR that would substantially reduce one of more significant effects, but the District decides not to adopt them.

The specific process the District will follow to ensure CEQA compliance as it moves forward implementing its Program is explained in greater detail below.

1.8.1 Future Activities

As discussed above, this PEIR evaluates the potential environmental impacts associated with the District's current Program and its future Program when the activities and materials can be identified at present. For activities and materials not within the current Program that are proposed at a future date to be included in the District's IVMP, the District will evaluate whether the proposed activity or material was within the scope of the Program evaluated within the PEIR and whether additional environmental documentation is required. Future activities not within the scope of the Program evaluated in the PEIR are considered "new actions" and may be subject to future environmental review under CEQA. All new actions will be subject to the District's BMPs and may be subject to mitigation measures identified in the PEIR, as appropriate, including new mitigation measures that may be identified as being necessary through potential future CEQA review. This section provides more information about the process by which the District will determine whether future activities are within the scope of the Program and the PEIR. The evaluation process for future activities is organized under two categories: chemical treatment and nonchemical treatment.

1.8.1.1 Future Chemical Treatments

All pesticides in current use have been evaluated in the PEIR (mostly under the Chemical Control Alternative), including the supporting Appendix B, *Ecological and Human Health Assessment Report*, along with a number of pesticides not currently in use but with the potential for use in the foreseeable future. A similar scenario occurs for herbicides. The herbicides most likely to be used are addressed under the Vegetation Management Alternative in this PEIR. Future formulations are likely to include ingredients already evaluated in this PEIR, as summarized below following the summary of the contents of Appendix B and materials that are exempt from USEPA reporting and use requirements.

1.8.1.2 Appendix B Summary and Exempt Materials

The PEIR's Appendix B reports on the evaluation of 42 pesticide (insecticides and herbicides) active ingredients and 4 adjuvants, for a total of 46 chemical ingredients used in 57 insecticides and 36 herbicides. An adjuvant is any compound that is added to an herbicide/pesticide formulation or tank mix to facilitate the mixing, application, or effectiveness of that herbicide/pesticide. The actual pesticide formulations used by the District are listed by active ingredient in Table 6-1 (insecticides) and Table 6-2 (herbicides). The PEIR also considers materials such as PBO, which acts as a synergist. Synergists are chemicals that primarily enhance the pesticidal properties of other active ingredients, such as pyrethrins and synthetic pyrethroids. No pesticide products contain only PBO.

Most chemicals produced for general or specialized uses are subject to a rigorous suite of dozens of laboratory and field tests to evaluate the relative toxicity of the ingredient(s) in the product proposed for use. As a result of the testing, the chemical is given one of four USEPA toxicity categories ranging from highly toxic to practically nontoxic (Category I - *highly toxic and severely irritating*; Category II - *moderately toxic and moderately irritating;* Category III - *slightly toxic and slightly irritating*; and Category IV - *practically nontoxic and not an irritant*). The tests used to develop these categories are designed to address potential toxicity to humans, but also to address the potential toxicity to nontarget aquatic and terrestrial species. Table 1-1 presents the USEPA toxicity categories for human health risk assessments.

Table 1-1 USEPA Toxicity Categories

Toxicity Study	Category I High Toxicity	Category II Moderate Toxicity	Category III Low Toxicity	Category IV Very Low Toxicity
Acute Oral	Up to and including 50 mg/kg	> 50 thru 500 mg/kg	> 500 thru 5,000 mg/kg	> 5,000 mg/kg
Acute Dermal	Up to and including 200 mg/kg	> 200 thru 2,000 mg/kg	> 2,000 thru 5,000 mg/kg	> 5,000 mg/kg
Acute Inhalation	Up to and including 0.05 mg/L	> 0.05 thru 0.5 mg/L	> 0.5 thru 2 mg/L	> 2 mg/L
Eye Irritation	Corrosive (Irreversible destruction of ocular tissue) or corneal involvement or irritation persisting for more than 21 days	Corneal involvement or irritation clearing in 8 to 21 days	Corneal involvement or irritation clearing in 7 days or less	Minimal effects clearing in less than 24 hours
Skin Irritation	Corrosive (tissue destruction into the dermis and/or scarring)	Severe irritation at 72 hours (severe erythema or edema)	Moderate irritation at 72 hours (moderate erythema)	Mild or Slight irritation (no irritation or slight erythema)

Note:

kg" is the body weight in kilograms as a universal metric for a reference. The toxicity is a function of the milligrams per kilogram (mg/kg) of body weight that elicits the noted response.

mg/L = milligram(s) per liter

USEPA also maintains a list of exempt and partially exempt chemicals for which the Chemical Data Reporting (CDR processing and use information is of "low current interest" and are listed in the USEPA CDR website and in the Federal Register at 40 Code of Federal Regulations [CFR] 711.6[b][2][iv]). Manufacturers of the chemicals in this category are exempt from reporting the processing and use information required and as defined by 40 CFR 711.15(b)(4).

The general category of exempt chemicals includes many culinary oils, specialized uses of common extracts of plants, and some chemicals consumed as food items, to name only a few. USEPA, at any time however, may amend the list of partially exempt chemicals on its own initiative or in response to a request from the public. The public may submit a petition to request that a chemical be added to or removed from the partial exemption.

1.8.1.3 Future Formulations

Future formulations are likely to be based on the existing active ingredients, adjuvants, surfactants, and synergists, and would be expected to have toxicity and potential effects similar to those reported in this PEIR. When considering a new pesticide formulation for use, the District will implement the following procedures to determine whether the information in this PEIR is applicable and sufficient to support the same conclusions on potential environmental impacts to human and ecological health or whether sufficiently different information identified that would mean additional evaluation and analysis under CEQA would be appropriate, prior to its inclusion in the District's IVMP.

1. Obtain the materials safety data sheets and laboratory test information on the new formulation or material from the company producing the product or from the appropriate federal or state regulatory agencies.

2. For the new formulation review, consider whether it is in the same toxicity hazard category as the active ingredients, adjuvants, and synergists addressed in this PEIR, or whether it has been classified as exempt by USEPA. The general toxicity hazard categories for humans, mammals, birds, fish, aquatic invertebrates, honeybees, and other receptors are found in Appendix B, Table 4-1 of the PEIR:
    a. Very Low
    b. Low
    c. Moderate
    d. High
    e. Nontoxic
3. If reported toxicity is similar to, or less than, the related formulation or material addressed in Appendix B, and the District does not have any evidence that the formulation or material would result in new significant impacts, or substantially more severe impacts, on human health and on ecological health that were not disclosed in the PEIR, then the District can reasonably proceed to make the finding that the information contained in the PEIR is sufficient to support a finding that no additional analysis under CEQA is required.
4. If the ingredients in the formulation have been classified as *Exempt* by USEPA, the District will independently review and evaluate the ingredients and product for efficacy and potential nontarget effects. If after this review, the evidence supports a finding that the new formulation or material will not have a new or substantially more severe significant effect than those included in the PEIR, the District can reasonably proceed to make the finding that no additional analysis under CEQA is required.
5. If the reported toxicity of the new formulation is greater than the reported toxicity in the PEIR for the similar formulation or material, leading to a conclusion that the use of the formulation by the District would result in new or substantially more severe significant impacts than those disclosed in the PEIR, then a subsequent PEIR would be prepared addressing the major revisions needed, or a supplemental PEIR would be prepared addressing any minor revisions needed, to adequately evaluate the new product for incorporation into the District's IMVMP.
6. If the new formulation contains ingredients that were not addressed in Appendix B, then an analysis of toxicity hazard will be conducted. If reported toxicity is similar to, or less than, the materials addressed in Appendix B, then the process under Step 3 above would apply. If the new formulation's toxicity is greater than the reported toxicity in the PEIR for similar formulation or material, then Step 5 would apply.

1.8.2 Future Nonchemical Treatments

1.8.2.1 Future Nonchemical Treatments by the District

Activities that are not a continuation of present operations and maintenance activities and that are not within the scope of the activities specifically addressed in the PEIR, and that involve physical modification of the environment or where special-status plant and animal species could potentially be affected, ("future activities"), would be subject to the following evaluation procedures to determine whether CEQA compliance has been achieved through this PEIR. The steps outlined below would be contained in a "checklist" for use by District staff to document its evaluation of the future activity.

Prior to initiating treatment, the District will conduct the following review to:

> Determine size and location of area to be physically modified or treated to ensure it is within scope of the District's USACE, San Francisco Bay Conservation and Development Commission (BCDC), and California State Water Resources Control Board (SWRCB) permits. These permits require the

preparation of annual work plans, and the USACE permit requires maps of the affected areas. The permits are issued after consultation with the appropriate resource agencies (such as CDFW and USFWS) and contain special conditions that address site-specific or species-specific considerations.

> Review request of another agency (e.g., flood control district, public works or sewerage agency) for physical control and/or vegetation management for coverage under existing permits of the agency or of the District.

> If the activity is outside of any of the District (or agency) work plans for that year, then is it considered an emergency action exempt from CEQA compliance. Emergency actions are not subject to CEQA requirements (CEQA Guidelines Section 15269), so no further CEQA analysis is required. A written evaluation/rationale will be provided in a staff report to District Board of Trustees.

> If an action is being carried out by a landowner or entity other than the District, and such entity requests that the District conduct such activities on their behalf, then the District will only consider doing so if the entity has satisfied all applicable legal requirements.[2]

> If action is not within the scope of the Program evaluated in the PEIR or exempt, then the landowner/land manager would prepare a CEQA Initial Study to determine what type of further environmental review is appropriate (e.g., PEIR addendum, negative declaration, mitigated negative declaration, or supplemental PEIR).

As part of any further environmental review (Initial Study, EIR, etc.), the landowner/land manager will be required to identify any potential impacts to special status species, through the following steps:

> Check CNDDB, USFWS, and other databases and studies for the area to determine if special status species or their habitat is present.

> If suitable habitat is present, do surveys for special status species, as required.

> If a special status species is (are) present, evaluate whether the proposed vector management activity can be scheduled around the species' critical life-stage periods to avoid disturbance.

> If the proposed vector management activity cannot be scheduled around a special status species' critical life-stage periods and must be performed because of imminent threat to public or animal health from the vector, confirm that the lowest impact effective vector management option is proposed for use.

> Engage in consultation with resource agencies.

Examples of activities that have not been addressed in a site-specific fashion in this PEIR are the various tidal marsh restoration projects planned for the North Bay to expand existing state and federal wildlife refuges, including the San Pablo Bay National Wildlife Refuge Sonoma Creek Enhancement Project and the Sears Point Restoration Project. The District is coordinating with the state and federal resource agencies on mosquito and vector management in the refuges.

1.8.2.2 Future Nonchemical Treatments by Landowners/Managers

As part of its mission to protect public health, the District advises landowners and land management agencies about the need for vector abatement with regard to their projects or when vector issues become an issue on their lands. The District does not manage land directly, as a park district or a property owner would; rather, it provides advice to the land manager/property owner on how to minimize the production of mosquitoes and other vectors of human disease and discomfort. The District derives its authority to proactively manage vector populations and protect public health from the Mosquito and Vector Control

[2] In these circumstances, the District's decision whether to act may be the only public agency decision if the requesting entity is a private party. In that event, if the District decides to act, it must comply with CEQA. The District may require landowners who request District assistance to pay for any necessary additional environmental work.

District Law (Health and Safety Code Sections 2000 et seq.). In enacting that law, the California Legislature recognized the importance to public health and the economy of active management of vectors.

Notwithstanding this grant of power, the law does not mandate action by the District and provides that landowners and land managers ultimately are responsible for the abatement of vector populations that breed on their properties and affect public health (Health & Safety Code, Section 2060). The District may provide guidance for mosquito abatement activities to landowners. However, it will be the landowner's responsibility to determine and comply with all legal requirements necessary to perform the activity.[3] For nonchemical actions that could be taken by landowners/managers at the recommendation of the District, District staff will advise the landowner/manager to consult further with the appropriate city or county planning agency on whether the activity is within the scope of the Program and PEIR, or whether there is a need for further CEQA analysis. If the activity is outside the scope of the Program, it may be necessary for the landowner/manager to conduct a site-specific survey of special status species. Consultations with appropriate resource agencies on survey protocols and any necessary permits would be initiated by the landowner/manager prior to conducting the surveys. Because the District's Service Area contains both urban and nonurban properties adjacent to or in close proximity with wildlife management and conservation areas, the need for close coordination with the refuge managers/resource agencies is paramount for such future activities.

The landowner/land manager is responsible for environmental review of physical control/vegetation management site-specific activities such as those proposed for recent marsh restoration and enhancement projects.

In cases outside of the federal wildlife refuges, and where the landowner does not address the mosquito problem, the District is authorized to manage vector populations (Health and Safety Code Section 2040). The District can request inspection and abatement warrants, if needed, to access and inspect properties that may be breeding/have the potential to produce vectors (Health and Safety Code Section 2053). Otherwise, landowner permission to enter is sufficient for the District to enter the property to conduct abatement activity. For example, abandoned swimming pools require immediate attention; if the landowner fails to abate the problem, the District may act. Mosquito abatement activities are often located on private property in urbanized areas that are not expected to provide habitat for special status species. The District would conduct only the activities addressed in this PEIR. Abatement actions by the District on private property are subject to the BMPs and PEIR mitigation measures, as appropriate. For those activities that are on public property, including parks and open-space areas, or on nonurbanized/undeveloped or "open" private property, where potential exists to encounter habitat for special status species, the District will follow the BMPs and mitigation measures identified in the PEIR, with the assistance of the landowner and resource agencies wherever possible. The District engages in public education and outreach to advise the landowner on reduction and prevention of vector habitats (see Section 2.4 of this PEIR). For discussion of required permits to perform abatement activity (in riparian habitats for vegetation removal and dirt work, discharges of pesticides into waters of the United States), whether the site is on or off a refuge, see Section 2.8.1 of this PEIR.

[3] CEQA applies where there is a discretionary approval of a project by a public agency. If the District is merely advising, and not authorizing an action, its action is not subject to CEQA. However, projects requiring approval by another public agency would be subject to CEQA.

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2 Program Description

2.1 Program Area and Vicinity

The Marin/Sonoma Mosquito and Vector Control District (Lead Agency and Program Sponsor) is preparing this PEIR to evaluate the effects of the continued implementation of a suite of control strategies and methods prescribed in its Integrated (Mosquito and) Vector Management Program (IVMP or Program). The District implements its Program primarily within a jurisdiction or Service Area of approximately 2,300 square miles with 736,000 residents. The activities described herein are conducted throughout Marin and Sonoma counties.

The environmental impact analysis of the Program will focus on the potential for impacts within Marin and Sonoma counties from the District's proposed Program and identify the potential for control activities within the Service Area to affect any adjacent jurisdictions. Under California law, the District also can take direct but limited action in adjacent areas bordering its Service Area (the Counties of Lake, Mendocino, Napa and Solano), if needed to provide control of mosquitoes and other vectors originating in adjacent areas for the health and safety of residents of the immediate Service Area [California Health and Safety Code Section 2240]. Control activities may also be provided in adjacent areas upon request of the adjacent jurisdictions to protect the health and safety of residents in adjacent jurisdictions. Actions that would be taken outside of the Service Area are the same types of actions undertaken within the Service Area and in similar types of habitats or sites. In summary, the Program occurs in an area that is somewhat larger than the District's Service Area; this larger area is called the Program Area, the area in which potential impacts could occur. The Program Area and its location within the State of California are shown on Figure 2-1, Marin/Sonoma Mosquito and Vector Control District Program Area.

Mosquito and/or vector control activities are conducted at a wide variety of locations or sites throughout the District's Service Area, including tidal marshes, duck clubs, other diked marshes, lakes and ponds, rivers and streams, vernal pools and other seasonal wetlands, stormwater detention basins, flood control channels, spreading grounds, street drains and gutters, wash drains, irrigated pastures, or agricultural ditches, as well as animal troughs, artificial containers, tire piles, fountains, ornamental fishponds, swimming pools, liquid waste detention ponds, and nonnatural harborage (such as covered wood piles, residential and commercial landscape, trash receptacles, etc.). Within the larger Program Area, activities would be conducted at similar sites.

2.2 Program Objectives

2.2.1 Purpose and Need

The District was established in 1915 to reduce the risk of vector-borne disease and discomfort to the residents of parts of Marin County, including issues involving large populations of salt marsh mosquitoes (e.g., *Aedes squamiger*). In 1976, central Sonoma County was added to the Service Area and in 2004, voters approved the annexation of the remaining territories of Marin and Sonoma Counties. In addition to being problematic by disrupting human activities and enjoyment of public and private areas, certain vectors can transmit a number of diseases. A vector is defined by the State of California as "any animal capable of transmitting the causative agent of human disease or capable of producing human discomfort or injury, including, but not limited to, mosquitoes, flies, other insects, ticks, mites, and rats, but not including any domesticated animal…" [California Health and Safety Code Section 2002(k)]. The vector-borne diseases currently of most concern in the Program Area are as follows, by the vector they are associated with:

> Mosquito-transmitted illnesses: WNV, WEE, SLE, dog heartworm, and malaria

> Tick-transmitted illnesses: Lyme disease, babesiosis, ehrlichiosis, tularemia, Spotted fever group *Rickettsia*, anaplasmosis, *Rickettsia* 364D.

> Rodent/rat-transmitted illnesses: leptospirosis, HPS, tularemia, plague

> Other vector-transmitted illnesses: murine typhus transmitted by fleas (usually on rats)

Depending on the disease, both human and domestic animal health can be at risk of disability, illness, and/or death. Furthermore, potential exists for introduction and transmission of new diseases by current vectors and for new disease vectors to be introduced into the District's Service Area. An example of this is the recent discovery of *Aedes albopictus* (i.e., Asian tiger mosquito) and *Aedes aegypti* (i.e., yellow fever mosquito) mosquitoes in central and southern California. These mosquito species are known to be vectors of diseases such as Chickungunya virus, yellow fever, and Dengue fever.

Yellow jacket wasps and several mosquito species in the Program Area are currently not of primary concern with respect to transmission of a disease or pathogen; however, they are vectors (see State of California definition above) in that they can inflict serious discomfort and injury (e.g., secondary infections) to residents and livestock. For example, employing the District's IVM Program to conduct surveillance and control for mosquito species such as *Aedes washinoi* (flood water mosquito), *Aedes sierrensis* (Western treehole mosquito), *Aedes dorsalis* (Pale marsh mosquito), and *Aedes squamiger* (California salt marsh mosquito) is important to prevent growth in populations of these species that can create discomfort and injury-related issues with residents, businesses, schools, agricultural operations, etc.

2.2.2 Program Objectives

The District undertakes vector control activities through its Program to control and/or provide information on the following vectors of disease and/or discomfort in the Program Area: mosquitoes, cockroaches, fleas, flies, rats, mice, ticks, and yellow jackets The District also performs vegetation management (including control of noxious and/or invasive plants) to facilitate access to vector habitat, improve efficiency and effectiveness of mosquito control operations, and as a source reduction measure.

The Proposed Program's specific objectives are as follows:

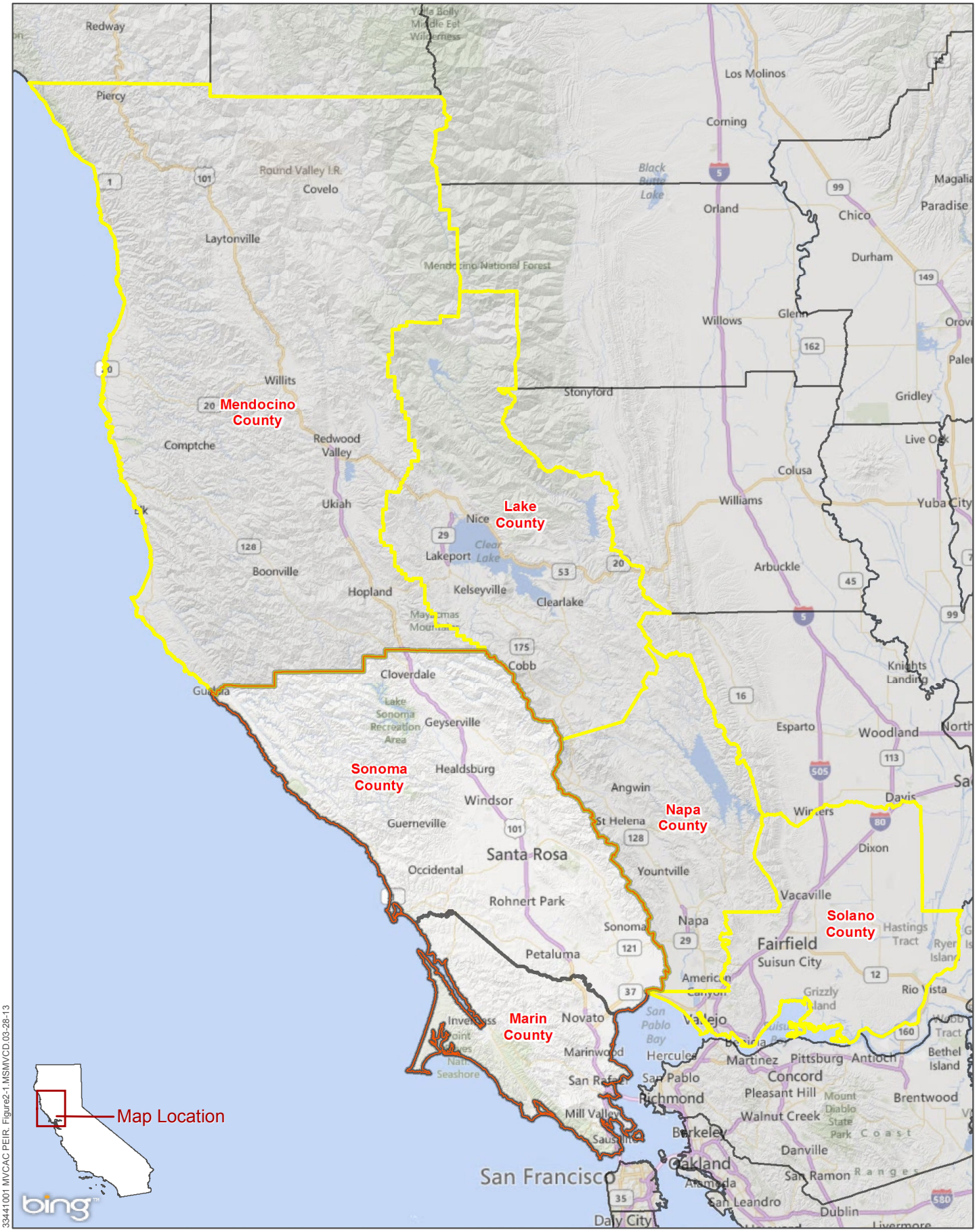
> Reduce the potential for human and animal disease caused by vectors

> Reduce the potential for human and animal discomfort or injury from vectors

> Accomplish effective and environmentally sound vector management by means of:

  - Surveying for vector presence, abundance, distribution, human and animal contact or potential for human and animal contact
  - Monitoring and surveying for vector-borne diseases and their antecedent factors that initiate and/or amplify disease
  - Establishing treatment guidelines
  - Appropriately selecting from a wide range of Program tools or components

Most of the relevant vectors are quite mobile and cause the greatest hazard or discomfort at a distance from where they breed. Each potential vector has a unique life cycle, and most of them occupy several types of habitats. To effectively control them an IVMP must be employed. District policy is to identify those species that are currently vectors, to recommend techniques for their prevention and control, and to anticipate and minimize any new interactions between vectors and humans and domestic animals.



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Source: Cardno ENTRIX, 2013

Service Area

Adjacent Counties

0 5 10 20

Scale in Miles

N

INTEGRATED VECTOR MANAGEMENT PROGRAM PEIR

Marin/Sonoma Mosquito & Vector Control District

Figure 2-1 - Program Area

2.3 Proposed Program

The District's Program is an ongoing series of related actions for the management of mosquito, rat, mice, yellow jacket, and tick populations to minimize human vector interactions and the associated risks of disease and discomfort. The District's activities involve the identification of vector problems; responsive actions to control existing populations of vectors, prevention of new sources of vectors from developing, and management of habitat to minimize vector production and facilitate access for surveillance and control; education of landowners and others on measures to minimize vector production or interaction with vectors; and provision and administration of funding and institutional support necessary to accomplish District objectives.

The District has, for at least the past 2 decades, taken an integrated systems approach to mosquito and vector control, utilizing a suite of tools that consists of public education, surveillance, source reduction (e.g., physical control, vegetation management, water management), biological, and chemical controls. These Program "tools" or components are described in the subsequent subsection as "Program alternatives" for the CEQA process (except for public education, which is exempt from CEQA). Program implementation is weighted heavily towards source reduction and biological control, in part, to reduce the need for chemical control. To realize effective and environmentally sound vector management, vector control must be based on several factors:

> Carefully monitoring or surveying vector abundance and/or potential contact with people

> Carefully monitoring and surveying for vector-borne diseases and their antecedent factors that initiate and/or amplify disease

> Establishing treatment guidelines

> Selecting appropriate tools from a wide range of control methods

This Program consists of a dynamic combination of surveillance, treatment guidelines, and use of multiple control activities in a coordinated program with public education that is generally known as Integrated Pest Management (IPM) or Integrated Vector Management (IVM), when focused on vector control.

While these Program components or tools together encompass the District's Program, it is important to acknowledge that the specific tools District staff use vary from day to day and from site to site in response to the vector species that are active, their population size or density, their age structure, location, time of year, local climate and weather, potential for vector-borne disease, proximity to human populations, including (a) proximity to sensitive receptors, (b) District staff's access to vector habitat, (c) abundance of natural predators, (d) availability and cost of control methods, (e) effectiveness of previous control efforts at the site, (f) potential for development of larvicide or adulticide resistance in vector populations, (g) landowner policies or concerns, (h) proximity to special-status species, and (i) applicability of Endangered Species Recovery Plans, Habitat Conservation Plans (HCPs), Natural Community Conservation Plans (NCCPs), and local community concerns, among other variables. Therefore, the specific actions taken in response to current or potential vector activity at a specific place and time depend on factors of vector and pathogen biology, physical and biotic environment, human settlement patterns, local standards, available control methods, and institutional and legal constraints. While some consistent vector sources are exposed to repeated control activity, many areas with minor vector activity are not routinely treated, and most of the land within the District's Service Area has never been directly treated for vectors.

The District's IVM Program (or IVMP), like any IPM program, seeks by definition to use procedures that will minimize potential environmental impacts. The District's IVMP employs IPM principles by first determining the species and abundance of mosquitoes/vectors through evaluation of public service requests and field surveys of immature and adult mosquito/vector populations and, then, if the populations exceed treatment guidelines, using the most efficient, effective, and environmentally sensitive means of control. For all vector

species, public education is an important control strategy. In some situations, water management or other physical control activities can be instituted to reduce mosquito-breeding sites. The District also uses biological control such as stocking or use of mosquitofish in some settings including: ornamental fish ponds waste ponds, water troughs, water gardens, fountains, and unmaintained swimming pools. When these approaches are not effective, or are otherwise deemed inappropriate, then larvicides and/or adulticides are used to treat specific vector producing or vector harboring areas.

Three core tenets are essential to the success of a sound IVMP.

> First, a proactive approach is necessary to minimize impacts and maximize successful vector management. Elements such as thorough surveillance and a strong public education program make all the difference in reducing potential human vector interactions.

> Second, long-term environmentally based solutions (e.g., water management, reduction of harborage and food resources, exclusion, and enhancement of predators and parasites) are optimal as they reduce the potential pesticide load in the environment as well as other potential long- and short-term impacts.

> Lastly, utilizing the full array of options and tools (public education, surveillance, physical control, biological control, and when necessary chemical control) in an informed and coordinated approach supports the overall goal of an environmentally sensitive vector management program.

The District's Program consists of the following alternatives, which are general types of coordinated and component activities, as described below: surveillance, physical control, vegetation management, biological control, chemical control, and nonchemical control/trapping. The Proposed Program is a combination of these alternatives with the potential for all of these alternatives to be used in their entirety along with public education.

Chemical methods to manage vectors and vector habitat (and noxious weeds in some cases), under the Vegetation Management and Chemical Control alternatives described below) are employed independently at specific application sites. The pesticides used as part of the District's Proposed Program are applied at low concentrations (appropriate for the vector involved) to avoid potential impacts to nontarget organisms from acute and/or chronic exposures. Manufacturers carefully establish application amounts mandated by product use requirements for treatment efficacy and low potential risk to nontarget organisms, and these amounts are substantially below the thresholds used for toxicity studies in the laboratory. The pesticides applied by the District degrade rapidly in the environment, thereby reducing the opportunity for environmental persistence. Some of the mosquito larvicide formulations used by the District, when applied according to the manufacturers' label instructions, are designed to provide residual control from approximately 21 up to 150 days. Several of these larvicides are classified as biochemical, biorational, or biological larvicides (e.g., Altosid pellets and XR briquettes, MetaLarv, VectoLex). As different materials are selected for potential rotational use in a given area (i.e., larvicides first, followed by adulticides if needed), District staff take care both in the selection of the materials used and the application process so that co-exposures to nontarget receptors are highly unlikely. This type of practice reduces the probability of additive or synergistic effects that could occur as a result of simultaneous exposures to more than one chemical. Once an area has been treated, the District determines the effectiveness of that treatment by subsequent monitoring of the mosquito population (at all life stages) and would treat again at the same site if the population counts were not reduced sufficiently. Treatment effectiveness is measured by various means including visual observation, larval sampling, and/or trapping of adult mosquitoes. The number and location of incoming service requests is also taken into account.

Synergists, and in some cases adjuvants (used with pesticides/herbicides to also facilitate mixing and application), are applied to increase the efficacy of some chemical control measures. This application could lead to co-exposures of synergists such as PBO and primary chemical treatments. However, synergists allow for reduced treatment amounts of primary pesticide chemicals, since their performance is improved via conjunctive use. Another example of chemicals sometimes used together is the co-application of methoprene and Bti. This particular treatment is employed to prevent pesticide resistance

and to ensure the control of all larval stages of mosquitoes while minimizing the potential for impacts to nontarget receptors from co-exposures.

2.3.1 Surveillance Alternative

Vector surveillance, which is an integral part of the District's responsibility to protect public health and welfare, involves monitoring vector populations and habitat, their disease pathogens, and human/vector interactions. Vector surveillance provides the District with valuable information on what vector species are present or likely to occur, when they occur, where they occur, how many there are, and if they are carrying disease or otherwise affecting humans. Vector surveillance is critical to an IVMP because the information it provides is evaluated against treatment guidelines to decide when and where to institute vector control measures. Information gained is used to help form action plans that can also assist in reducing the risk of vector-borne disease transmission and the occurrence of discomfort and injury to residents and livestock. Equally important is the use of vector surveillance in evaluating the efficacy, cost effectiveness, and environmental impacts of specific vector control actions.

2.3.1.1 Mosquito Surveillance

Mosquitoes in nature are distributed within their environment in a pattern that maximizes their survival to guarantee reproductive success. Immature stages develop in water and later mature to a winged adult that is capable of both long- and short-range dispersal. This duality of their life history presents vector control agencies with unique circumstances that require separate surveillance strategies for the aquatic versus terrestrial life stages.

Surveillance involves monitoring the abundance of mosquito populations, their habitat, mosquito-borne disease pathogens, and the interactions between mosquitoes and people over time and space. The District routinely uses a variety of traps for surveillance of adult mosquitoes, conducts regular field investigation of known mosquito sources for direct sampling for immature stages, responds to public service requests for larval and adult mosquitoes, and uses low ground pressure all-terrain vehicles (ATVs) to access these sites when necessary. The District conducts surveillance by way of a variety of activities that include:

> Field counting/sampling and use of trapping, along with the laboratory analysis of mosquitoes, their hosts, and pathogens to evaluate population densities and potential disease threats such as WNV, WEE, and SLE. Sampling of presence and abundance of mosquito populations tends to occur in areas where the citizenry would have a likelihood of exposure to them; field counts take place both at immature and adult stages of mosquito development or life cycle. Four kinds of traps, host-seeking traps, light traps, gravid/oviposition traps, and emergence traps, are used as described below:

  - *Host-seeking traps* typically use dry ice (carbon dioxide) to attract female mosquitoes behaviorally cued to seek a host to blood feed. The trap's components include a dry ice container, battery power source, a low ampere motor/fan combination, an LED light source, and a collection container for holding captured adults.
  - *Light traps* (commonly called New Jersey Light traps) use a source of photo-attraction such as an incandescent lamp (25 watt) or compact fluorescent lamp (7 watt) where mosquitoes are pulled in by the suction provided by an electric (110 v AC) appliance motor/fan combination. Mosquitoes picked up by the suction are directed downward (via screened cone) inside the trap body to a plastic collection jar containing a 1-inch strip of Vapona, Hot Shot®, or No-Pest® strip (dichlorvos).
  - *Oviposition traps* are used to collect gravid *Culex* spp. mosquitoes and/or to measure their egg-laying activity. As an example, they may use 5-day-old hay-infused water contained in a small plastic dish pan that has a 6-volt battery-operated fan directly above to draw the gravid female mosquitoes into the small collection net.

- *Emergence traps* are used to assess mosquito breeding in habitats that are difficult to access with a larval dipper, to study seasonal adult emergence patterns, and to estimate daily adult emergence or productivity. These types of traps are positioned on or above the water surface in order to collect mosquito samples and typically consist of some form of floating conical box, suspended cage, or sticky trap. The pyramid shaped, floating trap with a collection jar at the apex is the design most frequently used.

Mosquito immatures include eggs, four larval stages, and a transitional pupal stage. Mosquito control agencies routinely target the larval and pupal stages to preclude an emergence of adults. Operation evaluation of the presence, abundance, and distribution of immature mosquitoes is limited to the larval and pupal stages, although the District may sample eggs for research reasons. The District uses other lures such as octanol, a commercially manufactured "human-lure" and a solution made by the District staff and comprised of brewer's yeast, water and lactalbumin hydrolysate powder. Emergence traps are typically a pyramid shaped, floating trap with a collection jar at the apex that collects adult mosquitoes as they emerge from the water surface. Sampling and collection of the immature stages (egg, four larval stages, and a transitional pupal stage) involves the use of a 1-pint dipper (a standardized small plastic pot or cup-like container on the end of a 36-inch handle), which scoops up a small amount of water from the mosquito-breeding site. Although utilized infrequently, aquatic traps can also be used to sample mosquito larvae. Operationally, the abundance of the immatures in any identifiable "breeding" source is measured through direct sampling, which provides relative local abundance as the number of immatures per unit volume or area of the source. This method requires access by field personnel to within about 3 feet of larval sites at least every 2 weeks in warm weather. The spatial patchiness of larvae requires access to multiple locations within each source, rather than to single "bell-weather" stations.

> "Arbovirus"[1] surveillance to determine the likelihood and occurrence of mosquito-borne illness is accomplished by two methods commonly used in California: (1) capturing and testing female vector mosquitoes for the presence of mosquito-borne encephalitis viruses as explained above and (2) periodic testing for the presence of encephalitis virus-specific antibodies in the blood serum of either sentinel chickens or wild birds. The first method involves the use of host-seeking traps to capture female vector mosquitoes. Captured females are sorted into groups of up to 50 (called pools) and submitted to UC Davis or a laboratory local to that District to test for the presence of mosquito-borne viruses. The District uses the second method through the placement of caged chickens as "sentinel birds," and deploying adult mosquito traps to sample and conduct laboratory analyses of mosquito populations (e.g., Real-Time Polymerase Chain Reaction (PCR)) Since the viruses that are currently of major concern (WNV, WEE, and SLE) are diseases actively transmitted by mosquitoes to both birds and to humans through bites, caged chickens' routine blood samples will reveal whether one or more of the virus-specific antibodies are present. The chickens are placed generally 10 to a caged area (at least 6 by 12 feet or larger), are humanely handled, and are provided ample shelter with nest boxes, water, and feed. Chickens are used as the early detection system for virus transmission, as they are unaffected by the presence of these viruses in their systems. At the end of the mosquito season, the chickens are adopted out. In addition, dead birds reported by the public to the statewide WNV Hotline are mapped to determine high-risk areas, and those meeting testing criteria are brought to the District or sent to UC Davis to be tested for WNV.

> Field inspection of known or suspected habitats where mosquitoes live and breed. Sites where water can collect, be stored, or remain standing for more than a few days (72-96 hours) are potential habitats for mosquito breeding that require continuous inspection and surveillance. Water runoff into catch basins and stormwater detention systems from land uses including, but not limited to, residential communities, parks and recreation areas, and industrial sites, as well as ornamental ponds, unmaintained swimming pools, seeps/seepages, seasonal wetlands, tidal and diked marshes,

[1] Arthropod-borne viruses. The primary reservoir for the pathogens that cause these diseases is wild birds, and humans only become exposed as a consequence of an accidental exposure to the bite of infective mosquito vectors.

freshwater marshes, wastewater ponds, sewer plants, winery waste/agricultural ponds, managed waterfowl ponds, canals, creeks, streams, tree holes, tires, man-made containers, flooded basements/crawl spaces, and other standing waters are likely sources. Inspections of septic systems (the term is used here to encompass various types of conventional and alternative onsite wastewater treatment systems) for mosquito production are performed in response to public service requests. Indirect surveillance is conducted by setting adult mosquito traps on individual properties with septic systems or within neighborhoods.

> Maintenance of paths and clearings to facilitate sampling and to provide access to vector habitat, only where necessary. It is District policy that, whenever feasible, staff use preexisting roads, trails, walkways, and open areas to conduct routine and essential surveillance activities with the least impact on the environment. Surveillance is conducted using ATVs, but offroad access is minimized and used only when roads and trails are not available or do not provide appropriate access. Annually, the District also performs vegetation maintenance to provide access routes into sources of mosquito production such as creeks, flood control/water conveyance channels, and seasonal wetlands. Some access for inspection is conducted on foot. Paths to be maintained will range in width from 3 to 6 feet across.

> Analysis of public service requests and surveys and other methods of data collection. The District's mosquito surveillance activities are conducted in compliance with accepted federal and state guidelines, in particular the *California Mosquito-Borne Virus Surveillance & Response Plan* (CDPH et al. 2013) and *Best Management Practices for Mosquito Control in California* (CDPH and MVCAC 2012). These guidelines recognize that local conditions will necessarily vary and, thus, call for flexibility in selection and specific application of control methods.

2.3.1.2 Tick Surveillance

The District performs surveillance of ticks (e.g., *Ixodes pacificus*, *Dermacentor variables & occidentalis*) to reduce incidence of Lyme disease (*Borrelia burgdorferi*), *ehrlichia*, tularemia, *Rickettsia* 364D and Spotted fever group *Rickettsia* by way of the following practices:

> Collection of ticks in public contact areas to (a) determine the location of ticks infected with tick-borne pathogens and (b) to determine the seasonal and geographical distribution of the ticks according to species. Ticks are collected by "flagging" vegetation along trails. Stiff fabric is dragged for specified distances along the trails to stimulate ticks to attach to the material. Then they are manually removed and placed in vials for transport back to the laboratory for testing, or submission to other government agencies or diagnostic laboratories.

> Identification of ticks brought in by the public, which are usually found biting persons or their domestic animals.

> Submission of ticks to a lab to determine if they are infected with a pathogen such as the organisms that cause Lyme disease, tularemia, and/or Rocky Mountain spotted fever. The District refers individuals to the appropriate lab for testing ticks that may have been attached to a person or animal.

> Dissemination of educational information to the public concerning Lyme disease, ticks, and other tick-borne diseases.

2.3.1.3 Rodent Surveillance

The monitoring and control of rats and mice focuses on domestic rats including Norway rats (*Rattus norvegicus*), roof rats (*Rattus rattus*), and on house mice. Norway rats are known to invade homes and businesses from the sanitary sewers. Dissemination of information, public and agency education, and property inspections in response to public service requests involve looking for entry ways, rodent burrows, signs of rodent infestation, and source reduction (e.g., sanitation, harborage, and food sources).

Testing for the presence of HPS is occasionally conducted by collecting wild rodents. Although performed infrequently, hantavirus surveillance, small traps are placed in suspect areas including peridomestic habitats along the urban fringe or rural areas. The traps are checked the following day to remove any rodents for sampling. Wild rodent collection for disease surveillance requires a Scientific Collecting Permit from CDFW and is conducted in compliance with CDPH and CDC guidelines. Blood samples are submitted to CDPH for testing.

2.3.1.4 Yellow Jacket and Other Wasps

Venomous biting insect encounters often require District staff's response. It is important to educate the residents that while these insect stings may potentially induce life-threatening allergic reactions and pain, overall, these insects can serve beneficial roles as pollinators and biological control agents.

The District responds to public service requests and provides recommendations and control on nonstructural pest populations of yellow jackets. The District also provides information and referrals regarding the biology and removal (if necessary) of bee hives and wasp nests.

2.3.2 Physical Control Alternative

Managing vector habitat to reduce vector production or dispersal, either directly or through public education is often the most cost-effective and environmentally benign element of an IVMP. This approach to the control of vectors and other pests is often called "physical control" to distinguish it from those vector management activities that directly rely on application of chemical pesticides (chemical control) or the introduction or relocation of living agents (biological control). Other terms that have been used for vector habitat management include "source reduction," which emphasizes the significance of reducing the habitat value of an area for vectors, or "permanent control," to contrast with the temporary effectiveness of pesticide applications.[2] Vector habitat management is important because its use can virtually eliminate the need for pesticide use in and adjacent to the affected habitat and, in some situations, can virtually eliminate vector production from specific areas for long periods of time, reducing the potential disturbances associated with frequent biological or chemical control activities. The intent is to reduce the abundance of vectors produced or sheltered by an area while protecting or enhancing the habitat values of the area for desirable species. In many cases, physical control activities involve restoration and enhancement of natural ecological functioning, including production and dispersal of special-status species and/or predators of vectors.

2.3.2.1 Mosquitoes

Source Reduction (i.e., Physical Control) for mosquitoes consists of the management of mosquito-producing habitat (including freshwater marshes and lakes, saltwater marshes, temporary standing water for 72 to 96 hours or more, and wastewater treatment facilities) especially through water control and maintenance or improvement of channels, tide gates, levees, and other water control facilities. Physical control is usually the most effective mosquito control technique because it provides a long-term solution by reducing or eliminating mosquito developmental sites and ultimately reduces and potentially eliminates the need for chemical applications. The physical control practices may be categorized into three groups: maintenance, new construction, and cultural practices.

[2] This terminology can be misleading if periodic maintenance is needed for physical control devices or structure.

Maintenance activities are conducted within tidal, managed tidal, and nontidal marshes, seasonal wetlands, diked, historic baylands, and in some creeks adjacent to these wetlands. They include connection of backwaters or isolated pools on floodplains to the main channels of streams and rivers and increased drainage rates and areas in managed wetlands. The following activities are classified as maintenance:

> Removal of sediments from existing water circulation ditches

> Repair of existing water control structures

> Removal of debris, weeds, and emergent vegetation in natural channels

> Clearance, trimming, and removal of brush for access to streams and wetland areas

> Filling of existing, nonfunctional water circulation ditches to achieve required water circulation dynamics and restore ditched wetlands

New construction typically involves the creation of new ditches to enhance tidal flow preventing stagnant water.

Cultural practices include water management, placing culverts or other engineering works, and making other physical changes to the land. They reduce mosquito production directly by improving water circulation and indirectly by improving habitat values for predators of larval mosquitoes (fish and invertebrates), or by otherwise reducing a site's habitat value to mosquito larvae.

The District performs these physical control activities in accordance with all appropriate environmental regulations (e.g., wetland fill and dredge permits, endangered species review, water quality review, streambed alteration permits, see Section 2.7), and in a manner that generally maintains or improves habitat values for desirable species. Major physical control activities or projects (beyond the scope of the District's 5-year regional wetlands permits with the United States Army Corps of Engineers (USACE), San Francisco Bay Regional Water Quality Control Board (RWQCB), State Water Resources Control Board (SWRCB), and San Francisco Bay Conservation and Development Commission (BCDC) are not addressed under this PEIR (because they are not known at this time). Minor physical control activities (covered by the regional wetlands permits) are addressed in this PEIR. They vary substantially from year to year, but typically consist of up to 10,000 linear feet of ditch maintenance. Under the regional permits, the District's work plans are reviewed annually by trustee and other responsible agencies prior to initiation of the planned work. USACE, USFWS, CDFW, and other responsible agencies can inspect documentation of completed work.

The District may request/require landowners and stewards to maintain and clear debris from drainage channels and waterways; excavate built-up spoil material; remove water from tires and other urban containers; cut, trim, mow, and harvest aquatic and riparian plants (but not including any mature trees, special status plant species[3], or sensitive habitat areas); and perform minor trenching and ditching. The District may provide guidance for mosquito abatement activities to landowners and stewards. However, it will be the responsibility of the landowner to determine and comply with all legal requirements necessary to perform the activity. District policy is that with every recommendation, the District also makes it clear to the landowner the requirement for consultation with resource agencies and acquisition of permits that may be needed prior to commencement of any work.

The remainder of this subsection describes physical control or "source reduction" practices by type of potential mosquito habitat.

[3] Special-status species are those that are listed as endangered, threatened or candidate species under the federal Endangered Species Act, endangered or threatened under the California Endangered Species Act, or listed as species of special concern by the State of California.

2.3.2.1.1 Freshwater Habitats

The District Service Area includes a number of areas, generally man-made, that are permanently ponded with fresh water. Examples include the margins of reservoirs with shallow water and emergent vegetation, artificial ponds for holding drinking water for livestock, and retention ponds created for holding of rainwater. Some retention ponds have been constructed within freeway interchanges and others have been built in cities and towns to provide flood protection and to deal with hydromodification and storm water treatment issues. Natural lakes are usually not a mosquito problem because most of the water is deep, and little emergent vegetation may exist.

Source reduction activities to control mosquito populations in freshwater habitats, i.e., marshes and ponds, generally consist of consultation with landowners, land stewards, and/or regulatory agencies to implement measures including constructing and maintaining channels to reduce mosquito production, vegetation management, and water level management in floodplains and marshes. The primary principle governing source reduction is to manipulate water levels in low-lying areas and/or to reduce vegetation abundance to eliminate or reduce mosquito populations and the need for chemical control applications. Physical control of mosquitoes in nontidal habitats typically involves improving the habitat value or dispersal potential of the site for mosquito predators; reducing the habitat value for mosquitoes through vegetation management, increased circulation, steepening banks, or changes in water quality; or by reducing the duration of standing water in areas that produce mosquitoes by filling small areas or improving drainage. Filling or draining artificially ponded areas (low spots in flood-irrigated fields, etc.) can be cost-effective and environmentally acceptable, but is not an appropriate strategy in natural areas (however small), large permanent water bodies, or in areas set aside for stormwater or wastewater retention. In such situations, the other options are more appropriate. At this time, the District is rarely involved in new drainage projects. However, the District does maintain or assist with the maintenance of some existing drainage systems. This maintenance can include upkeep of gates and other water control structures, excavating accumulated spoil materials, and vegetation management such as cutting, mowing, clearing debris, and/or herbiciding overgrown vegetation (see Section 2.3.3 for vegetation management including the use of herbicides).

Ditches are a traditional technique for mosquito control, and they function in a number of ways. In addition to providing drainage if they lead from high to low ground, ditches can serve as a larvivorous fish (i.e., fish that eat mosquito larvae) reservoir. As rainfall increases, larvivorous fish move outward to adjacent areas to prey on immature mosquitoes, and as water levels decrease, larvivorous fish retreat to water in the ditches. Also, sills or weirs constructed in ditches can intentionally decrease water flow, decrease emergent aquatic weeds, prevent depletion of the water table, and allow larvivorous fish year-round refuge. Over the past several decades, urban development has occurred in areas where mosquito control drainage ditches have existed as the primary drainage systems. In many cases, maintenance responsibility for mosquito control projects has been taken over by city and county public works departments and integrated into their comprehensive stormwater management programs.

The District considers two mosquito control strategies when advising on freshwater source reduction for mosquito habitat. One strategy involves reducing the amount of standing water or reducing the length of time that water can stand in low areas following significant rainfall or artificial flooding events. In light of this strategy, District staff will advise or require landowners to construct channels or ditches with control elevations low enough to allow for a certain amount of water to leave an area before immature mosquitoes can complete their life cycle. However, the District does not encourage land managers and/or owners to alter vernal pool and seasonal wetland habitats, especially those managed for waterfowl. The District may also recommend, advise upon, or manage water control structures to manage mosquito production while also meeting the needs of the agency or landowner. The other strategy relies on vegetation management (see Section 2.3.3). District staff will advise or require landowners to remove or thin vegetation to improve surveillance or reduce mosquito habitats. District policy is that with every recommendation, the District also makes it clear to the landowner the requirement for consultation with resource agencies and acquisition of permits that may be needed prior to commencement of any work.

As environmental laws, including Clean Water Act Section 404, greatly restrict mosquito habitat manipulations in freshwater habitats, the District is generally precluded from undertaking permanent physical control of these areas. Consequently, the District does not usually undertake physical control projects in freshwater bodies including marshes, vernal pools, and ponds.

2.3.2.1.2 Seasonal Wetlands and Vernal Pools

The Service Area's Mediterranean climate results in large numbers of seasonally flooded areas, which may produce large numbers of mosquitoes during part of the year. Vernal pools are a specific type of seasonally flooded wetland, distinguished by a subsurface hardpan and often an assemblage of protected plants and invertebrates. Peripheral areas of tidal and historically tidal marshes can produce mosquitoes in response to seasonal rains, as well as following unusually high tides. Physical control methods include those described above for nontidal habitats. Physical control in vernal pools typically consists of the District reviewing project plans and providing design and access related suggestions, vegetation management, and adjustments related to water residency time in manmade vernal pools.

The District has long-standing cooperative and collaborative relationships with CDFW, professional biologists and property owners with regard to access, mosquito surveillance and control in association with vernal pools. District staff have received information and training from CDFW and professional biologists with respect to minimizing the potential for impacts to vernal pool habitat and specifically California tiger salamander (*Ambystoma californiense*), Sebastopol meadowfoam *(Limnanthes vinculans*), Burke's goldfields (*Lasthenia burkei)*, and Sonoma sunshine (*Blennosperma bakeri*). The District avoids performing mosquito surveillance and control on rainy days or during dawn and dusk to avoid peak movement periods for California tiger salamander.

When using ATVs to perform mosquito control in the proximity of vernal pools, District staff stay outside of the margin of the vernal pools (delineated by vegetation change from wetland to upland), and avoid operating ATVs within wetland vegetation or the actual vernal pool. When possible, District staff performs mosquito control on foot with hand equipment, or by operating ATVs in upland areas a considerable distance from the pools and walking from the ATV to the pools to perform mosquito control (e.g., using a long hose reel based on the ATV). When it is necessary to use an ATV for mosquito surveillance and control in proximity to vernal pools, the District utilizes low ground pressure vehicles. District staff operates ATVs at slow speeds on sites containing vernal pools, and remains observant while operating equipment and walking in and amongst vernal pool habitat.

The District reviews project plans regarding vernal pool construction (e.g. mitigation banks) and communicates with property owners and project biologists regarding the relationship of mosquito source reduction and vernal pool hydrology and vegetation management and the occurrence of unwanted vegetation such as cattails. The District communicates with the Interagency Review Team that oversees vernal pool development projects and participates in interagency meetings and field trips.

2.3.2.1.3 Freshwater Marshes and, Waterfowl Management Areas

Within federal, state, and privately held properties, a number of marshes have been created and operated to provide aquatic habitats for wildlife, especially waterfowl. Some of these marshes are drained and refilled periodically to enhance the primary productivity of the habitat, and under certain circumstances, can result in large populations of mosquitoes. Examples of these types of habitats occur along the Highway 37 corridor and along Highway 101 in close proximity to the cities of Sonoma, Petaluma, and Novato. Physical control methods include those described above for nontidal habitats.

2.3.2.1.4 Saline and Brackish Habitats

Saline and brackish marsh habitats of concern are along the edge of San Francisco and San Pablo bays. Most of these are subject to tidal action, but they can include reclaimed or other brackish/salt marshes that are not subject to natural tidal action. These brackish areas are usually contained by levees, ditches,

or other water control structures. Physical control measures are those used for freshwater marshes (nontidal) and increasing tidal circulation such as:

> Circulation ditches to enhance drainage, water circulation/exchange or to allow larvivorous fish access to mosquito breeding locations (with enhancement through the creation of permanent water bodies that act as predatory fish reservoirs

> Small ditches formed by a speed scavel that are up to 18 inches wide and 18 inches deep to enhance water circulation

> Ditching which involves the construction or maintenance of shallow ditches usually 2 feet wide and 18 inches deep and up to 6 feet wide and 4 feet deep using high-speed rotary equipment with the spoil material evenly distributed in a very thin layer over the marsh surface with limitations on its use based on the size of ditch needed, soil types, access, adjacent terrain, and vegetation present

> Impoundments that involve keeping a sheet of water across a salt-marsh substrate

> Rotational impoundment management (RIM), which is a formal strategy of impoundment management that achieves multipurpose management by allowing the impoundment to (1) control salt-marsh mosquito production from the marsh through means other than insecticides, (2) promote survival and revegetation by maintaining open periods and sufficiently low water levels during the summer flooding period, and (3) allow marine life to use the previously unavailable impounded high marsh.

> Excavation using a low ground pressure excavator

These ecologically sensitive areas require careful implementation of any physical modifications to avoid damage to the habitat and sensitive species that may be present. Physical control measures can reduce salt-marsh mosquito production through enhancement of the frequency and duration of tidal inundation or through other water management strategies.

2.3.2.1.5 Temporary Standing Water and Artificial Ponds

Temporary standing water can occur from a variety of conditions including irrigation of parks, golf courses, and agricultural fields in addition to ponding from rainfall events in natural areas. As environmental laws generally prevent/restrict draining or filling of small artificial ponds, the District employs other options that are effective in controlling mosquitoes, which include periodic draining, providing deepwater sanctuary for larvivorous fish, managing emergent and standing vegetation, and maintaining steep banks. Improved drainage is one effective tool for source reduction in such habitats. The second is the use of proper irrigation practices for those agricultural areas that require artificial watering. Proper water management, land preparation, adequate drainage, source reduction, and equipment maintenance are the most effective means of physically controlling mosquitoes in these types of sources. The District provides technical assistance to landowners regarding mosquito source reduction and developing effective water management systems on certain lands.

Pond management options that are effective in controlling mosquitoes include periodic draining, providing deepwater sanctuary for larvivorous fish, working with landowners to identify leaky pipes, and advising management of emergent, floating and standing vegetation, and maintain steep banks when appropriate. The District routinely advises landowners on the BMPs for ponds to reduce mosquito development. The District also advises landowners to consult regulatory agencies regarding the need for agency consultation and permitting for ponds with natural habitat that could potentially support native species.

2.3.2.1.6 Riparian Areas

Control measures will vary depending on the density of the human population, proximity of special status species, the vector potential of the mosquito causing the complaint, and access to the larval breeding or adult resting habitat. Minor physical control activities with insignificant environmental impacts can potentially be accomplished using hand tools to connect small ponded areas to the channel along the

edge of streams with highly variable flows. Generally, thick brush, complex microtopography, and variability of the conditions in these habitats preclude extensive physical control in these areas, or chemical control is generally more effective.

2.3.2.1.7 Tree Holes

Control measures are very limited here due to the large numbers of tree holes in most impacted areas, difficulties in access, concerns for staff safety, and in some cases the age and size of the tree (heritage trees). The control methods used are also dependent on the location and numbers of people and pets affected by the mosquitoes produced from this habitat. Current control measures include public education, filling of some holes with sand or other inert materials (absorbent gel) to displace larval habitat, or chemical control (larvicides, adulticides).

2.3.2.1.8 Wastewater Treatment Facilities/Septic Systems

Wastewater recycling and reuse help to conserve and replenish freshwater supplies. Concern for water quality conditions in lakes, rivers, and marine areas has resulted in the enactment of new state laws that will greatly limit future disposal of wastewater into these aquatic systems. To adjust to these changing conditions, many communities must implement wastewater reuse and recycling programs. Mosquito problems are frequently associated with some of the conventional wastewater treatment operations and the expanded use of wastewater recycling and reuse by both municipal and commercial/industrial operations, which may inadvertently create even more mosquito habitats.

Pond management options that are effective in controlling mosquitoes include periodic draining, providing deepwater sanctuary for larvivorous fish, minimizing emergent, floating and standing vegetation, and maintaining steep banks. The District routinely advises property owners on the BMPs for ponds to reduce mosquito development.

Onsite wastewater treatment systems, such as septic tanks and associated drainfields are designed to keep all flows below the ground surface. In the event of system failure, sewage or leachate could under certain circumstances flow laterally into nearby swales and ditches, especially in rural areas. Physical control requires maintenance and repair of these systems by the property owner. If mosquito production is found within a septic system, the resident and/or property owner are informed of source reduction measures that need to be researched and implemented if applicable. Examples of source reduction measures include inspecting septic tank lids for cracks (and repairing the cracks), ensuring the lid gasket (if so equipped) is in good condition and that a proper seal occurs when the fasteners are tightened, Other measures include determining whether tank risers are present and exposed and that they are free of cracks, ensuring that all vents to the system including those on the roof of the building are completely covered with durable 1/16-inch mesh screen type material.

In Marin County, onsite wastewater treatment systems are regulated by County Environmental Health staff under authority granted by the San Franciso Bay RWQCB. In Sonoma County, the Permit and Resource Mangement Department regulates onsite wastewater treatment systems under authority granted by both the San Franciso Bay RWQCB and the North Coast RWQCB. In both counties, staff investigate complaints of system failures and issue corrective measures and repair permits as appropriate. They also issue construction permits for new systems and renewable operating permits for newer designs of onsite wastewater treatment systems, which incorporate requirements for regular mandatory inspections to ensure that these systems continue to function properly.

2.3.2.1.9 Artificial Container Habitats

Artificial containers, such as flowerpots, cans, barrels, and tires, provide opportunities for mosquitoes to breed in urban areas. A container-breeding mosquito problem can be solved by properly disposing of such materials, covering them, or tipping them over to ensure that they do not collect water. The District

utilizes house-to-house surveillance and public education programs to address urban container-breeding mosquito problems.

2.3.2.2 Other Vectors

Physical control for other vectors such as yellow jackets, wasps, ticks, rats and mice, is based on public education and can involve site inspections by the District to determine conditions promoting harborage and signs of infestation. Property owners are provided educational materials on control measures that include removal of food sources (such as pet food, bird/squirrel feeders, and fruit from trees) and blockage of access points into the structure. If the vector shows signs of disease, has been involved in human or pet contact incident, or is otherwise posing an immediate health or safety risk, then the appropriate agency or pest control operator most often employs removal by trapping or shooting.

Three elements are necessary for a successful rodent management program: sanitation, exclusion, and rodent proofing.

> *Sanitation*: Correcting sanitation deficiencies is basic in rodent control. Eliminating food sources through good sanitation practices will prevent an increase in their populations. Sanitation involves good housekeeping, including proper storage and handling of food materials and pet food. For example, store pet food in metal, rodent-proof containers, clean up bird seed spillage, and pick up tree fruit that is on the ground. For roof rats, thinning dense vegetation will make the habitat less desirable. Algerian or English ivy, star jasmine, and honeysuckle on fences or buildings are very conducive to roof rat infestations and should be thinned or removed if possible.

> *Exclusion of rodents*: Sealing cracks and openings in building foundations, and any openings for water pipes, electric wires, sewer pipes, drain spouts, and vents is recommended. No hole larger than ¼ inch should be left unsealed to exclude both rats and house mice. Doors, windows, and screens should fit tightly. Their edges can be covered with sheet metal if gnawing is a problem. Coarse steel wool, wire screen, and lightweight sheet metal are excellent materials for plugging gaps and holes.

> *Rodent proofing* against roof rats requires more time to find entry points than for Norway rats because of their greater climbing ability. Roof rats often enter buildings at the roofline area so be sure that all access points in the roof are sealed. If roof rats are traveling on overhead utility wires, the District recommends/encourages the property owner to contact a pest control professional or the utility company for information and assistance with measures that can be taken to prevent this access.

While activities designed to reduce vector populations through changes in the physical environment are considered Physical Control, they must be distinguished from activities related to rearing or relocating predators of vectors, which are discussed below as “Biological Control,” as well as those tools that impact vector habitat through manipulation of vegetation, which are described below as “Vegetation Management” practices.

2.3.3 Vegetation Management Alternative

The species composition and density of vegetation are basic elements of the habitat value of any area for mosquitoes and other vectors, for predators of these vectors, and for protected flora and fauna. District staff periodically undertake vegetation management activities, or encourage and provide suggestions others how to do so on their property, as a tool to reduce the habitat value of sites for mosquitoes and other vectors or to aid production or dispersal of vector predators, as well as to allow District staff’s access to vector habitat for surveillance and other control activities. District staff’s direct vegetation management generally consists of activities to reduce the mosquito habitat value of sites by improving water circulation or access by fish and other predators, or to allow District staff ‘s access to standing water and known sources of mosquito production for inspections and treatment.

For vegetation management, the District uses hand tools or other mechanical means (i.e., heavy equipment) for vegetation trimming, removal or thinning and sometimes applies herbicides (chemical

pesticides with specific toxicity to plants) under the cooperating agencies' permitting, in order to improve surveillance or reduce vector habitats and often improve general habitat value. Vegetation removal or thinning primarily occurs in aquatic habitats to facilitate access to sources of mosquito production for surveillance and control. To reduce the potential for mosquito breeding associated with water retention and infiltration structures, District staff may systematically clear weeds and other obstructing vegetation in wetlands and retention basins (or request the structures' owners to perform this task). In particular, thinning and removal of emergent vegetation overgrowth (e.g., cattails) would be done to provide a maximum surface coverage of 30 percent or less. In some sensitive habitats and/or where sensitive species concerns exist, vegetation removal and maintenance actions would be restricted to those months or times of the year that minimize disturbance/impacts. Vegetation management is also performed to assist other agencies and landowners with the management of invasive/nonnative weeds (e.g., Spartina, Pepperweed, Arundo, Tamarix, and Ailanthus). These actions are typically performed under the direction of the appropriate agency, which also maintains any required permits.

Tools ranging from shovels and pruners to chain saws and "weed-whackers" up to heavy equipment can all be used at times to trim or clear plant matter that either prevent access to mosquito breeding sites or that prevent good water management practices that would minimize mosquito populations. Generally, however, District "brushing" activities rely almost entirely on hand tools. Trimmed vegetation is either removed and disposed of properly from the site or broadcast in such a way as to minimize visual degradation of the habitat. Trimming is also kept to a minimum to reduce the possibility of the invasion of exotic species of plants and animals. Surveys for special-status plants using the California Natural Diversity Database and other online sources of information including relevant HCPs, coordination with the landowner, and acquisition of necessary permits are completed before any work is undertaken. Follow-up surveys are also conducted to verify that the work undertaken was effective and that the physical manipulation of the vegetation did not result in any unintended overall habitat degradation.

In addition, the use of water management to control vegetation is in some ways an extension of physical control, in that water control structures created as part of a physical control project may be used to directly manipulate hydroperiod (flood frequency, duration, and depth) as a tool for vegetation management. Where potential evapotranspiration rates are high, water management can also become a mechanism for salinity management and, indirectly, vegetation management through another path.

Table 2-1 identifies the herbicides the District proposes to use to manage vegetation on District grounds for control of mosquito and other vector populations and/or to control invasive plant species (noxious weeds). Both Aquamaster (labeled for aquatic applications) and Roundup (labeled for terrestrial applications) are used for spot control of actively growing vegetation. All herbicides are applied in strict conformance with label requirements. Additional information on herbicides proposed for possible future use is contained in Appendix B (Table 3-2, Table 4-1, and Section 4.6).

2.3.4 Biological Control Alternative

Biological control of mosquitoes and other vectors involves the intentional use of vector pathogens (diseases), parasites, and/or predators to reduce the population size of target vectors. It is one of the principal components of a rational and integrated vector control management program. The effectiveness of a vector biological control agent lies in its ability to reduce vector numbers as quickly as possible. An ideal biological control agent feeds preferentially on the target vector, exhibits an extremely efficient hunting or parasitizing strategy, and reproduces quickly. Biological control is used as a method of protecting the public from vectors, the pathogens they transmit and occurrence of disease without the use of pesticides and potential problem of pesticide resistance; however, the use of pathogens involves USEPA-registered materials regulated and labeled as chemical insecticides. The different types of biological controls are described in the following paragraphs.

Table 2-1 Herbicides Proposed for Use by the Marin/Sonoma Mosquito and Vector Control District for Vegetation Management

Herbicides Product Name	Common Name/Active Ingredients	CAS or EPA Number	Mode of Action	Timing of Application	Method of Application	Sites
Alligare Imazapyr 2 SL	27.8% imazapyr	EPA # 81927-23	Amino acid synthesis inhibitor	Not currently used but would consider in the future	Truck mounted sprayer, backpack sprayer, hand can, ATV sprayer	Vegetation control along railroad lines, utility, pipelines, and highway right of ways.
Alligare Glyphosate 4 Plus	41% glyphosate	EPA # 81927-9	Shikimic acid pathway disrupter	Currently not used but would consider in the future.	Truck mounted sprayer, backpack sprayer, hand can, ATV sprayer	Management of woody brush including poison oak.
Alligare Glyphosate 5.4	53.8% glyphosate	EPA # 81927-8	Shikimic acid pathway disrupter	Not currently used but would consider in the future.	Truck mounted sprayer; backpack sprayer, hand can, ATV sprayer	Interior margins of waste water ponds, ditches, marshes
Alligare Triclopyr 3	44.4% triclopyr	EPA # 81927-13	Auxin mimic	Not currently used but would consider in the future.	Truck mounted sprayer, backpack sprayer, hand can, ATV sprayer	Woody plants, vines, Poison oak
Aquamaster	53.8% glyphosate	EPA # 524-343	Shikimic acid pathway disrupter	Not currently used but would consider in the future	Truck mounted sprayer; backpack sprayer, hand can, ATV sprayer	Interior margins of waste water ponds, ditches, marshes
Blazon Pattern Indicator	Polymeric Colorant (proprietary)	EPA # 352-346	N/A	Not currently used but would consider in the future.	Truck mounted sprayer; backpack sprayer, hand can, ATV sprayer	Interior margins of waste water ponds, access roads, levees, marshes
Bullseye Spray Pattern Indicator	Polymeric Colorant (proprietary)	Exempt	N/A	Not currently used but would consider in the future.	Truck mounted sprayer; backpack sprayer, hand can, ATV sprayer	Interior margins of waste water ponds, access roads, levees, marshes
Competitor	Modified Vegetable Oil	CA Reg. No. 2935-50173	Adjuvant	Not currently used but would consider in the future.	Boat mounted sprayer, backpack sprayer, hand can, ATV sprayer	Interior margins of waste water ponds, access roads, levees, marshes

Table 2-1 Herbicides Proposed for Use by the Marin/Sonoma Mosquito and Vector Control District for Vegetation Management

Herbicides Product Name	Common Name/Active Ingredients	CAS or EPA Number	Mode of Action	Timing of Application	Method of Application	Sites
Ecomazapyr 2 SL	27.8% imazapyr	EPA # 74477-8	Amino acid synthesis inhibitor	Not currently used but would consider in the future.	Truck mounted sprayer, backpack sprayer, hand can, and boat mounted sprayer, ATV sprayer	Ponds, lakes, rivers, streams, ditches, reservoirs, swamps, bogs, marshes, seasonal wet areas, aquatic and terrestrial transition
Habitat	28.7% imazapyr	EPA # 241-426	Amino acid synthesis inhibitor	Spring - Fall	Truck mounted sprayer, backpack sprayer, hand can, and boat mounted sprayer, ATV sprayer	Ponds, lakes, rivers, streams, ditches, reservoirs, swamps, bogs, marshes, seasonal wet areas, aquatic and terrestrial transition
Liberate	Lecithin, methyl esters of fatty acids, alcohol ethoxylate	CA Reg. No. 34704-50030	Surfactant Mixture	Spring - Fall	Boat mounted sprayer, backpack sprayer, hand can, ATV sprayer	Ponds, lakes, reservoirs, canals, ditches, marshes, wetlands
Imazapyr 4 SL	52.6% imazapyr	EPA # 74477-5	Amino acid synthesis inhibitor	Not currently used but would consider in the future	Truck mounted sprayer, backpack sprayer, hand can, ATV sprayer	Vegetation control along forested roads and non-irrigation ditch banks.
Li 700	80% Phosphatidylcholine, methyl acetic acid and alkyl polyoxyethylene ether	CA Reg # 34704-50035	Adjuvant	Spring - Fall	Truck mounted sprayer, backpack sprayer, hand can, and boat mounted sprayer, ATV sprayer	Grasslands, pastures, aquatic sites, wetlands
Polaris	27.7% imazapyr	EPA # 228-534	Amino acid synthesis inhibitor	Not currently used but would consider in the future	Truck mounted sprayer, backpack sprayer, hand can, and boat mounted sprayer, ATV sprayer	Aquatic vegetation control in estuarine marine surface water.

Table 2-1 Herbicides Proposed for Use by the Marin/Sonoma Mosquito and Vector Control District for Vegetation Management

Herbicides Product Name	Common Name/Active Ingredients	CAS or EPA Number	Mode of Action	Timing of Application	Method of Application	Sites
Pro-Spreader Activator	90% alkyl phenol ethoxylate, isopropanol, and fatty acids	CAS # 1050775-50022-AA	Adjuvant	Not currently used but would consider in the future	Truck mounted sprayer, backpack sprayer, hand can, ATV sprayer	Agricultural, forestry, turf and ornamental, industrial and non-cropland sites.
Ranger Pro	41% glyphosate	EPA # 524-517	Shikimic acid pathway disrupter	Spring - Fall	Truck mounted sprayer, backpack sprayer, hand can, ATV sprayer	Agricultural, turf and ornamental
Renovate 3	44.4% triclopyr	EPA # 62719-37-67690	Auxin mimic	Not currently used but would consider in the future.	Truck mounted sprayer, backpack sprayer, hand can, ATV sprayer	Ponds, lakes, reservoirs, canals, ditches, marshes, wetlands
Rodeo	53.8% glyphosate	EPA # 62719-324	Shikimic acid pathway disrupter	Spring - Fall	Truck mounted sprayer, backpack sprayer, hand can, ATV sprayer	Wetlands, agricultural
Roundup Pro Max	48.7% glyphosate	EPA # 524-579	Shikimic acid pathway disrupter	Not currently used but would consider in the future	Truck mounted sprayer, backpack sprayer, hand can, ATV sprayer	Management of woody brush including poison oak.
Roundup Pro	41% glyphosate	EPA # 524-475	Shikimic acid pathway disrupter	Spring – Fall	Truck mounted sprayer, backpack sprayer, hand can, ATV sprayer	Management of woody brush including poison oak.
Round Up	41% glyphosate	EPA # 524-445	Shikimic acid pathway disrupter	Spring – Fall	Truck mounted sprayer, backpack sprayer, hand can, ATV sprayer	Management of woody brush including poison oak, ornamental, turf

Table 2-1 Herbicides Proposed for Use by the Marin/Sonoma Mosquito and Vector Control District for Vegetation Management

Herbicides Product Name	Common Name/Active Ingredients	CAS or EPA Number	Mode of Action	Timing of Application	Method of Application	Sites
Tri-Fol	25% Aliphatic Polycarboxylate, 9.0% Calcium Chloride	CA Reg # 2935-50152	Acidifier & Buffering Agent	Spring - Fall	Truck mounted sprayer, backpack sprayer, hand can, ATV sprayer	Terrestrial sites and crops
Turf Trax Blue	Polymeric Colorant (proprietary)	Exempt	N/A	Late Spring – Fall	Boat mounted sprayer, backpack sprayer, hand can, ATV sprayer	Ponds, lakes, reservoirs, canals, ditches, marshes, wetlands

CAS Number = Chemical Abstracts Service Registry Number
EPA Number = Registered with the Environmental Protection Agency
N/A = Not Applicable

2.3.4.1 Mosquito Pathogens

Mosquito pathogens include an assortment of viruses and bacteria. Pathogens are highly host-specific and usually infect mosquito larvae when they are ingested. Upon entering the host, these pathogens multiply rapidly, destroying internal organs and consuming nutrients. The pathogen can be spread to other mosquito larvae in some cases when larval tissue disintegrates and the pathogens are released into the water to be ingested by uninfected larvae. Examples of viruses that can infect mosquitoes are mosquito iridoviruses, densonucleosis viruses, nuclear polyhedrosis viruses, cytoplasmic polyhedrosis viruses, and entomopoxviruses. Examples of bacteria pathogenic to mosquitoes are *Bacillus sphaericus* (Bs), the several strains of *Bacillus thuringiensis israelensis* (Bti), and *Saacharopolyspora spinosa*. Two bacteria, Bs and Bti, produce proteins that are toxic to most mosquito larvae, while *Saacharopolyspora spinosa* produces compounds known as spinosysns, which effectively control all larval mosquitoes. Bs can reproduce in natural settings for some time following release. Bti materials the District applies do not contain live organisms, but only spores made up of specific protein molecules.

All three bacteria are naturally occurring soil organisms that are commercially produced for use as mosquito larvicides. Because the potential environmental impacts of Bs or Bti application are generally similar to those of chemical pesticide applications, these materials and Spinosad are described below under the Chemical Control Alternative in Section 2.3.5 and are evaluated for environmental impacts in the resource sections under the Chemical Control Alternative. Bs is applied as a live organism for the management of immature mosquito populations and is, therefore, a mosquito pathogen or biological control agent. Similarly, because the byproducts of Bti and *Saacharopolyspora spinosa* (protein crystals and spinosyns) are used to control immature mosquitoes, and not the live organisms, these mosquito larvicides would actually be deemed chemical control agents.

2.3.4.2 Mosquito Parasites

The life cycles of mosquito parasites are biologically more complex than those of mosquito pathogens and involve intermediate hosts, organisms other than mosquitoes. Mosquito parasites are ingested by the feeding larva or actively penetrate the larval cuticle to gain access to the host interior. Once inside the host, parasites consume the internal organs and food reserves until the parasite's developmental process is complete. The host is killed when the parasite reaches maturity and leaves the host (*Romanomermis culicivorax*) or reproduces (*Lagenidium giganteum*). Once free of the host, the parasite can remain dormant in the environment until it can begin its developmental cycle in another host. Examples of mosquito parasites are the fungi *Coelomomyces* spp., *Lagenidium giganteum, Culicinomyces clavosporus*, and *Metarhizium anisopliae*; the protozoa *Nosema algerae, Hazardia milleh, Vavraia culicis, Helicosporidium* spp*., Amblyospora californica, Lambornella clarki*, and *Tetrahymena* spp.; and the nematode *Romanomermis culicivorax*. These parasites are not generally available commercially for mosquito control at present.

2.3.4.3 Mosquito Predators

Mosquito predators are represented by highly complex organisms, such as insects, fish, birds, and bats that consume larval or adult mosquitoes as prey. Predators are opportunistic in their feeding habits and typically forage on a variety of prey types, which allows them to build and maintain populations at levels sufficient to reduce or control mosquito populations, even when mosquitoes are scarce. Examples of mosquito predators include representatives from a wide variety of taxa: coelenterates, *Hydra* spp.; platyhelminths, *Dugesia dorotocephala, Mesostoma lingua, and Planaria* spp.; insects, *Anisoptera, Zygoptera, Belostomidae, Geridae, Notonectidae, Veliidae, Dytiscidae, and Hydrophilidae*; arachnids, *Pardosa* spp.; mosquitofish, *Gambusia affinis*, *Gasterosteus aculeatus*; bats; and birds, *anseriformes, apodiformes, charadriiformes, and passeriformes*. Only mosquitofish are commercially available to use at present, or able to be reproduced/reared, while the District supports the presence of the other species if practical (also see Section 15.2).

The District's use of mosquitofish in mosquito habitat is representative of the most commonly used biological control agent for mosquitoes in the world. These fish are ideal control agents for several reasons. They feed primarily at the water's surface, where larvae can be found. They can tolerate a significant range in water temperature and water quality. They are also easy to handle, transport, stock, and monitor. Correct use of this fish can provide safe, effective, and persistent suppression of a variety of mosquito species in many types of mosquito sources. As with all safe and effective control agents, the use of mosquitofish requires a good knowledge of operational techniques and ecological implications, careful evaluation of stocking sites, use of appropriate stocking methods, and regular monitoring of stocked fish. Mosquitofish reproduce in natural settings, for at least some time after release. Due to concerns that mosquitofish may potentially impact red-legged frog and tiger salamander populations, District policy is to limit the use of mosquitofish to ornamental fish ponds, water troughs, water gardens, fountains, unused swimming pools, and other types of isolated manmade ponds that do not provide habitat that could support native species and that are not connected to natural waterways. Limiting the introduction of the mosquitofish to these sources should prevent their migration or introduction into habitats used by threatened, endangered, or rare species.

Mosquitofish are no longer reared at District facilities but will be purchased from another district. Only a small stock of fish will be maintained on site to meet demand. On average, the District releases about 30 pounds of mosquitofish annually.

2.3.4.4 Other Vectors

No effective predators exist to control high rodent populations. Cats may provide short-term control when the rodent population is low, but they can impact bird populations. The District would not employ cats for rat control. Raptors cannot provide adequate rodent control in urban environments. Currently, no commercial biological control agents or products are available for wasp and yellow jacket control.

2.3.5 Chemical Control Alternative

Chemical control is a Program tool that consists of the application of nonpersistent (i.e., rapid chemical breakdown) insecticides (and herbicides noted in Section 2.3.3 above) to directly reduce populations of larval or adult mosquitoes and other invertebrate threats to public health (e.g., yellow jackets and ticks). Several of these insecticides are quite target specific when applied at labeled rates for mosquito control (e.g., Bti, Bs, methoprene). If and when inspections reveal that mosquitoes or other vector populations are present at levels that trigger the District's guidelines for chemical control – based on the vector's abundance, density, species composition, proximity to human settlements, water temperature, presence of predators and other factors – District staff will apply larvicides and/or adulticides to the site (including septic tanks/onsite wastewater management systems) in strict accordance with the label instructions. The total number of applications and weight or volumes of specific pesticides the District applied in Summer 2011 through Spring 2012 are presented in Appendix B, Attachment A (Tables A16 through A20) of this PEIR.

2.3.5.1 Mosquito Abatement

Annually, the great majority of the District's chemical control applications are for the purposes of mosquito control. The primary pesticides used can be divided between "larvicides," which are specifically toxic to mosquito larvae, and "adulticides," which are used to control adult mosquito populations. These pesticides and their applications are described in the following paragraphs.

2.3.5.1.1 Mosquito Larvicides

Larvicides are applied when the chemical control guidelines for mosquito larvae are present and application rates vary according to time of year, water temperature, the level of organic content in the water, the type of mosquito species present, larval density, and other variables. Larvicide applications may be repeated at any site at recurrence intervals ranging from annually to weekly.

Larvicides the District routinely uses include Bti, Bs, Methoprene (Altosid or MetaLarv), CocoBear™ Oil, BVA-2, and Agnique.

> *Bacillus thuringiensis israelensis* (Bti) is a biological larvicide. Bti is a bacterium that is ingested by mosquito larvae and disrupts their gut lining, leading to death before pupation. The District applies Bti as a liquid or bonded to an inert substrate (sand or corncob granules) to assist penetration of vegetation. Persistence is low in the environment, and efficacy depends on careful timing of application to coincide with periods in the life cycle when larvae are actively feeding. Pupae and late 4th instar stage larvae do not feed and, therefore, will not be controlled by Bti. Low water temperature inhibits larval feeding behavior, reducing the effectiveness of Bti during very cold periods. High organic conditions also reduce the effectiveness of Bti. Therefore, use of Bti requires frequent inspections of larval sources during periods of larval production, and may require frequent applications of material. Application can be by hand, from an ATV, truck, watercraft, or from aircraft (e.g., helicopter).

> *Bacillus sphaericus* (Bs) is a biological larvicide. Bs is a bacterium that when ingested by mosquito larvae produces microbial gut toxins that destroy the insect gut wall, leading to paralysis and death. Bs is a biological larvicide the District applies as a liquid or bonded to an inert substrate (corncob granule) to assist penetration of vegetation. The mode of action is similar to that of Bti, but Bs may be used more than Bti in some sites because of its higher effectiveness in water with higher organic content and residual properties that allow longer larvicidal action. Persistence is low in the environment, and efficacy depends on careful timing of application to coincide with periods in the life cycle when larvae are actively feeding. Pupae and late 4th instar stage larvae do not feed and, therefore, will not be controlled by Bs. Low water temperature inhibits larval feeding behavior, reducing the effectiveness of Bs during very cold periods. Bs is also ineffective against certain mosquito species such as those in the genus *Aedes*. Knowing the stage and species present can increase the effectiveness of this material, restricting it to sources containing susceptible species. Therefore, use of Bs requires frequent inspections of larval sources during periods of larval production and may require frequent applications of material. Application can be by hand equipment, from an ATV, truck, watercraft, or from aircraft (e.g., helicopter).

> Spinosad is an Organic Materials Review Institute Listed Dow AgroSciences active ingredient that is a fermentation product of bacteria first discovered in an old rum distillery. Spinosad is a fermentation product of the naturally occurring soil bacterium *Saacharopolyspora spinosa*. It causes excitation of the mosquito's nervous system, ultimately leading to paralysis and death. This mode of action makes this pesticide a good option for rotational use in the prevention of resistance. Its action on the target organism is either by contact or by ingestion, and as with other bacterial larvicides, activity can be reduced in highly organic water. Spinosad is applied as a liquid or as a sustained-release product that can persist for up to 30 or 180 days. It is applied either in response to high observed populations of mosquito larvae at a site or as a sustained-release product that can persist for up to about 4 months. This product has very low potential for accumulation in soil or groundwater contamination. Application can be performed by hand equipment, from a truck, ATV, from watercraft, or from aircraft.

> Methoprene, currently under the trade names Altosid, and MetaLarv, is a synthetic juvenile hormone that is designed to disrupt the transformation of a juvenile mosquito into an adult. Methoprene products must be applied (or present, if using a slow release formula) to the late instar (e.g., third and fourth) stages of the mosquito lifecycle. It is not effective against other life stages. Methoprene can be applied in granular, liquid, pellet, or briquet formulation. Sustained-release products can persist for up to 30 or 150 days. Application can be performed by hand, from a truck, ATV, from watercraft, or from aircraft.

> BVA-2 and Masterline Mosquito Larvicide are highly refined petroleum distillates (mineral oil). These new larvicides/pupacides demonstrate a low level of toxicity to plant growth (phytotoxicity) and rapid environmental breakdown. BVA-2 larvicide/pupacide oil has a water-white clear color and is also practically odorless. It forms a thin film on water and kills larvae through suffocation and/or direct

toxicity. It is typically applied at application rates of 3 to 5 gallons per acre and can be applied by hand, from an ATV, from watercraft, truck, or aircraft.

> Agnique is the trade name for a surface film larvicide, comprised of ethoxylated alcohol that kills mosquito larvae and pupae differently than BVA-2. Agnique causes larval mosquito mortality by physically altering the surface tension of the water while BVA 2 is a suffocant. The District uses Agnique as an alternative to BVA-2 although costs, limits of application, and effective duration are issues that require consideration when considering the use of this material. This product can be applied by hand, ATV, watercraft, truck, or aircraft. Agnique forms an invisible monomolecular film that is odorless and visually undetectable. This film interrupts the critical air/water interface (surface tension) in the mosquito's larval and pupal development cycle causing them to drown. Because the layer is thin, larvae can still temporarily penetrate the film to get air allowing for them to survive for up to 5 days. Mortality rate is somewhat dependent on life-cycle stage. Larvae are typically killed within 48 to 72 hours; however, with some species and under certain environmental conditions (such as cool temperatures when development is slow) larval control may take upwards of 120 hours. Water temperature will affect oxygen demands and rate of maturation, thus slowing control. Pupae are typically controlled within 24 to 72 hours, and any pupae that attempt to emerge will be controlled due to the presence of the film.

> CocoBear™ Oil is a new larvicide/pupacide that consists of 10% white mineral oil, >75% proprietary blend of methyl esters of fatty acids, <5% manufacturer undisclosed alcohol ethoxylate surfactant, and <1% of another undisclosed proprietary component. This product has replaced the discontinued Golden Bear Oil 1111. This new larvicide has similar characteristics and properties to Golden Bear Oil 1111 in that it also demonstrates low-level toxicity to plant growth (phytotoxicity) and rapid environmental breakdown. It forms a thin film on water and kills larvae through suffocation and/or direct toxicity. It is typically applied at application rates of 3 to 5 gallons per acre and can be applied by hand, from an ATV, from watercraft, from a truck, or from aircraft (e.g., helicopter).

Mosquito pathogens and other larvicides most likely to be used are listed in Table 2-2 (Pathogens and Other Larvicides Marin/Sonoma Mosquito and Vector Control District Uses for Mosquito Abatement). Anthropogenic sources are defined as sources of vector production that are caused or produced by humans such as, tires, ornamental water features, manmade ponds and wastewater treatment systems, septic systems, neglected swimming pools, etc.

Larviciding Techniques

Because of the wide range of mosquito sources in the Service Area, and the variety of pesticide formulations described above, the District uses a variety of techniques and equipment to apply larvicides, including handheld sprayers, backpack sprayers and blowers, truck-or-ATV-mounted spray rigs, watercraft, and helicopters or other aircraft. See Section 2.6 for more detailed information on equipment the District uses. District guidelines for selecting application methods are predicated upon access, efficiency and effectiveness of application, size of the area to be treated, and the density and type of vegetation present at the application site (i.e., the likelihood of success in applying the material to the target area).

Ground Larviciding Techniques

The District uses conventional pickup trucks and ATVs (e.g., Argos) as larvicide vehicles. A chemical container tank, high-pressure, low-volume electric or gas pump, and spray nozzle are mounted in the truck bed, with a switch and extension hose allowing the driver and/or an assistant to operate the equipment and apply the larvicide. The ATVs have a chemical container mounted on the vehicle, a 12-volt electric pump supplying high-pressure, low-volume flow, and booms and/or hose and spray tips allowing for application while steering the vehicle. ATVs are ideal for treating areas such as agricultural fields, pastures, and other offroad sites. Additional training in minimizing habitat impacts, recognizing sensitive flora and fauna, and ATV safety and handling is provided to employees before operating these machines.

Table 2-2 Pathogens and Other Larvicides Marin/Sonoma Mosquito and Vector Control District Uses for Mosquito Abatement

Pesticide Product Name	Common Name/ Active Ingredients	Chemical Type	CAS or EPA Number	Mode of Action	Timing of Application	Method of Application	Sites
Pathogens/Biological Control							
Agnique MMF Mosquito Larvicide & Pupacide	Biodegradable, alcohol ethoxylated surfactant 100% liquid	Larvicide/ Pupacide Surface Film	53263-28	Larvicide/Pupacide; monomolecular film that disrupts surface tension causing larvae and pupae to drown.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
Agnique MMF G	Biodegradable, alcohol ethoxylated surfactant 100% granule	Larvicide /Pupacide Surface Film	53263-30	Larvicide/Pupacide; monomolecular film that disrupts surface tension causing larvae and pupae to drown.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
AquaBac 400G	Bti 5.71% granule	Microbial	62637-13	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
AquaBac xt	Bti 8.0% liquid	Microbial	62637-1	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
BVA 2 Mosquito Larvicide Oil	Mineral Oil 97%	Larvicide/P upacide Oil	70589-1	Larvicide/pupacide; film spreads over water surface and inhibits larvae and pupae from obtaining oxygen (breathing) resulting in suffocation.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
CocoBear™ Oil		Larvicide/P upacide Oil	TBA	Larvicide/pupacide; film spreads over water surface and inhibits larvae and pupae from obtaining oxygen (breathing) resulting in suffocation.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
FourStar 45	Bs 6% Bti 1% 45 day briquet	Microbial	83362-3	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand	Anthropogenic sources, manmade and natural wetlands, waterways, marshes

Table 2-2 Pathogens and Other Larvicides Marin/Sonoma Mosquito and Vector Control District Uses for Mosquito Abatement

Pesticide Product Name	Common Name/ Active Ingredients	Chemical Type	CAS or EPA Number	Mode of Action	Timing of Application	Method of Application	Sites
FourStar 90	Bs 6% Bti 1% 90 day briquet	Microbial	83362-3	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
FourStar 180	Bs 6% Bti 1% 180 day briquet	Microbial	83362-3	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
FourStar SBG	Bti 2.15% granule	Microbial	85685-1	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
MetaLarv S-PT	(S)-Methoprene 4.25% granule	Insect Growth Regulator	73049-475	Insect Growth Regulator – Interrupts metamorphosis – Interferes with maturation	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
VectoBac 12AS Biological Larvicide	Bti, 11.61% liquid	Microbial	73049-38	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
VectoBac G Biological Larvicide	Bti, 2.8% granule	Microbial	73049-10	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
VectoBac GS Biological Larvicide	Bti, 2.8% granule	Microbial	73049-10	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
VectoBac WDG Biological Larvicide	Bti, 37.4% water dispersible granule	Microbial	73049-56	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes

Table 2-2 Pathogens and Other Larvicides Marin/Sonoma Mosquito and Vector Control District Uses for Mosquito Abatement

Pesticide Product Name	Common Name/ Active Ingredients	Chemical Type	CAS or EPA Number	Mode of Action	Timing of Application	Method of Application	Sites
VectoBac Technical Powder Biological Larvicide	Bti 100% for granulation mix	Microbial	73049-13	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
VectoLex CG Biological Larvicide	Bs 7.5% granule	Microbial	73049-20	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
VectoLex WDG Biological Larvicide	Bs 51.2% water dispersed granule	Microbial	73049-57	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
VectoLex WSP Biological Larvicide	Bs, 7.5% granule in water soluble packets	Microbial	73049-20	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
VectoMax CG Biological Larvicide	Bs, 2.7% and Bti 4.5% granule	Microbial	73049-429	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
VectoMax WSP Biological Larvicide	Bs, 2.7% and Bti 4.5% granule	Microbial	73049-429	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
Zoecon Altosid Briquets	(S)-Methoprene 8.62%	Insect Growth Regulator	2724-375	Insect Growth Regulator – Interrupts metamorphosis – Interferes with maturation	Jan.-Dec.	Hand	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
Zoecon Altosid XR Extended Residual Briquets	(S)-Methoprene 2.1%	Insect Growth Regulator	2724-421	Insect Growth Regulator – Interrupts metamorphosis – Interferes with maturation	Jan.-Dec.	Hand	Anthropogenic sources, manmade and natural wetlands, waterways, marshes

Table 2-2 Pathogens and Other Larvicides Marin/Sonoma Mosquito and Vector Control District Uses for Mosquito Abatement

Pesticide Product Name	Common Name/ Active Ingredients	Chemical Type	CAS or EPA Number	Mode of Action	Timing of Application	Method of Application	Sites
Zoecon Altosid Liquid Larvicide Concentrate	(S)-Methoprene 20%	Insect Growth Regulator	2724-466	Insect Growth Regulator – Interrupts metamorphosis – Interferes with maturation	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
Zoecon Altosid Liquid Larvicide Mosquito Growth Regulator	(S)-Methoprene 5%	Insect Growth Regulator	2724-392	Insect Growth Regulator – Interrupts metamorphosis – Interferes with maturation	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
Zoecon Altosid Pellets	(S)-Methoprene 4.25%	Insect Growth Regulator	2724-448	Insect Growth Regulator	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
Zoecon Altosid SBG Single Brood Granule	(S)-Methoprene 0.2%	Insect Growth Regulator	2724-489	Insect Growth Regulator – Interrupts metamorphosis – Interferes with maturation	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
Zoecon Altosid XR-G	(S)-Methoprene 1.5%	Insect Growth Regulator	2724-451	Insect Growth Regulator – Interrupts metamorphosis – Interferes with maturation	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
Larvicides the Marin/Sonoma Mosquito and Vector Control District May Use in the Future for Mosquito Abatement							
Agnique MMF G Pak 35	Biodegradable, alcohol ethoxylated surfactant 100% granule –water soluble pouch	Larvicide/Pupacide Surface Film	53263-30	Larvicide/Pupacide; monomolecular film that disrupts surface tension causing larvae and pupae to drown.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
Altosid Pellets WSP	(S)-Methoprene 4.25%	Insect Growth Regulator	2724-448	Insect Growth Regulator – Interrupts metamorphosis – Interferes with maturation	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes

Table 2-2 Pathogens and Other Larvicides Marin/Sonoma Mosquito and Vector Control District Uses for Mosquito Abatement

Pesticide Product Name	Common Name/ Active Ingredients	Chemical Type	CAS or EPA Number	Mode of Action	Timing of Application	Method of Application	Sites
AquaBac 200G	Bti 2.86% granule	Microbial	62637-3	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
FFAST Bti	Bti, 10% liquid	Microbial	432-1515	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
Kontrol Mosquito Larvicide	Mineral Oil 98%	Larvicide/P upacide Oil	737-48-10	Larvicide/pupacide; film spreads over water surface and inhibits larvae and pupae from obtaining oxygen (breathing) resulting in suffocation.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
Natular 2EC	Spinosad 20.6% liquid	Microbial	8329-82	Larvicide; microbial alters acetylcholine receptors causing involuntary neurological impacts.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
Natular G	Spinosad 0.5% granule	Microbial	8329-80	Larvicide; microbial alters acetylcholine receptors causing involuntary neurological impacts.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
Natular G30	Spinosad 2.5% granule	Microbial	8329-83	Larvicide; microbial alters acetylcholine receptors causing involuntary neurological impacts.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
Natular XRT	Spinosad 6.25% tablet	Microbial	8329-84	Larvicide; microbial alters acetylcholine receptors causing involuntary neurological impacts.	Jan.-Dec.	Hand	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
Spheratax SPH (50 G)	Bs 5% granule	Microbial	84268-2	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes

Table 2-2 Pathogens and Other Larvicides Marin/Sonoma Mosquito and Vector Control District Uses for Mosquito Abatement

Pesticide Product Name	Common Name/ Active Ingredients	Chemical Type	CAS or EPA Number	Mode of Action	Timing of Application	Method of Application	Sites
Spheratax SPH (50 G) WSP	Bs 5.0% granule in water soluble packets	Microbial	84268-2	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
Teknar SC	Bti 5.6% liquid	Microbial	73049-435	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
VectoBac GR	Bti granule	Microbial	TBA	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes
VectoMax G Biological Larvicide	Bs, 2.7% and Bti 4.5% granule	Microbial	73949-429	Larvicide; when ingested, produce microbial gut toxins that destroy insect gut wall leading to paralysis and death.	Jan.-Dec.	Hand /equipment, ATV, boat, truck, Aerial	Anthropogenic sources, manmade and natural wetlands, waterways, marshes

CAS Number = Chemical Abstracts Service Registry Number
EPA Number = Registered with the US Environmental Protection Agency
TBA = To be announced

Additional equipment used in ground applications of liquid formulations includes handheld sprayers (handcans or spray bottles), and backpack sprayers and blowers. Handheld sprayers (handcans) are standard 1- or 2- or 3-gallon garden style pump-up sprayers used to treat very small isolated areas. Backpack sprayers are either hand pump-up for liquid applications and have a 2.5/3 to 5-gallon tank or are gas powered with a chemical tank and calibrated proportioning slot. Generally, a pellet or small granular material is applied by hand or with a gas-powered backpack blower, ATV-mounted Herd Seeder, or hand crank "belly grinder" machine designed to evenly distribute the pellets or granules.

Using ground application equipment, both when on foot and when conveyed by vehicles, has several advantages. Ground larviciding allows applications while in close proximity to the actual treatment area and, consequently, treatments occur to only those microhabitats where larvae are actually present. This method also reduces both an unnecessary pesticide load on the environment and the financial cost of the amount of material used and its application. Both the initial and the maintenance costs of ground equipment are generally less than for aerial equipment. Furthermore, ground larviciding applications are less affected by weather conditions than are aerial applications.

However, ground larviciding is impractical for large or densely wooded/vegetated areas. Also, risk of chemical exposure for the applicators (workers) is greater than during aerial larviciding operations. Damage may occur from the use of a ground vehicle in some natural areas. Ruts and vegetation damage may occur, although both these conditions are reversible and generally short-lived. Technicians are trained to recognize sensitive habitat areas and to use good judgment to avoid and/or minimize impacting these areas.

Aerial Larviciding Techniques

When large areas, difficult to access areas, or areas with dense and/or abundant aquatic vegetation are producing mosquito larvae at densities exceeding District treatment guidelines, then the District may use helicopters or other aircraft to apply any of the larvicides discussed above or listed in Table 2-3. The District contracts with independent aerial applicators to perform applications, with guidance to the target site provided by District staff.

Aerial applications of larvicides are a relatively infrequent activity, typically making up only a small portion of the District's larvicide applications each year, with each application covering approximately 20 to 600 acres per operation.

The larvicides, excluding granular and pellet formulations, are typically combined with water and applied as a low-volume wet spray mix at 5 gallons per acre or less. When the volume of final mix is increased to 5 gallons per acre the actual amount of larvicidal active ingredient that is applied per acre does not change. Adjusting the final mix volume per acre to 5 gallons has the advantage of increasing the droplet size to help minimize potential drift, increase coverage and penetration in areas of dense vegetation. In especially problematic areas of relatively small acreage, application volumes can be increased to as much as 10 to 100 gallons per acre. The disadvantage of increasing the application rates is that doing so substantially increases the flying time, which also increases costs. Aerial application of liquid larvicides typically occurs during daylight hours and at an altitude above the treatment site of approximately 50 feet or less.

Granular and pellet formulations of larvicides are applied using a large mechanical spreader with a bucket (or hoppers on the side of the aircraft (e.g., Isolair) that can hold several hundred pounds of granules/material on the aircraft. Granular and pellet formulations are generally much more expensive than liquid formulations of larvicides and are used to penetrate dense vegetation. Application rates can range between 3 and 10 pounds per acre for pellets/granules impregnated with methoprene. Applications of methoprene pellets above 5 pounds per acre are highly unlikely due to the high cost. Applications are around 10 to 20 pounds per acre for corncob granules impregnated with Bti or Bs materials. Rates depend on the density of vegetative cover and the organic content of the mosquito breeding water being treated. It is also significant to note that granular applications occur during daylight hours and are at an altitude of approximately 50 feet or less.

Table 2-3 Adulticides Marin/Sonoma Mosquito and Vector Control District Uses for Mosquito Abatement

Pesticide Product Name	Common Name / Active Ingredients	CAS or EPA Number	Mode of Action	Timing of Application	Method of Application	Sites
Adulticides Used by the MSMVCD for Mosquito Abatement						
Pyrocide Mosquito Adulticiding Concentrate for ULV Fogging 7067	Pyrethrins 5 % PBO, Technical 25%	1021-1199	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, industrial, recreational and agricultural areas, swamps, marshes, overgrown waste areas, roadsides and pastures
Zenivex E20	Etofenprox 20%	2724-791	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, industrial, recreational areas, overgrown waste areas, athletic fields, woodlands, gardens, playgrounds, campsites, municipalities, etc.
Scourge 4%***	Resmethrin 4.14% Piperonyl Butoxide 12.42%	432-716	Insect nervous system stimulation	January - December	Hand equipment, truck, boat, ATV, **Aerial	e.g., Residential, industrial, recreational areas, overgrown waste areas, athletic fields, woodlands, gardens, playgrounds, campsites, municipalities, etc.
Adulticides Marin/Sonoma Mosquito and Vector Control District May Potentially Use in the Future for Mosquito Abatement**						
Allpro Evoluer 4-4 ULV	Permethrin 4% PBO 4%	769-982	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, industrial, recreational areas, overgrown waste areas, athletic fields, woodlands, gardens, playgrounds, campsites, municipalities, agricultural areas, etc.
Allpro Evoluer 30-30 ULV	Permethrin 30 % PBO Technical 30%	769-983	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, industrial, recreational areas, overgrown waste areas, athletic fields, woodlands, gardens, playgrounds, campsites, municipalities, agricultural areas, etc.

Table 2-3 Adulticides Marin/Sonoma Mosquito and Vector Control District Uses for Mosquito Abatement

Pesticide Product Name	Common Name / Active Ingredients	CAS or EPA Number	Mode of Action	Timing of Application	Method of Application	Sites
Anvil 10+10 ULV	3-Phenoxybenzyl-(1RS, 3RS, 1RS, 3SR)-2,2-dimethyl-3-(2 methylprop-1-enyl) cyclopropanecarboxylate 10% PBO 10%	1021-1688-8329	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, industrial, recreational areas, overgrown waste areas, athletic fields, woodlands, gardens, playgrounds, campsites, municipalities swamps, marshes, agricultural areas, etc.
Anvil 2+2 ULV	3-Phenoxybenzyl-(1RS, 3RS, 1RS, 3SR)-2,2-dimethyl-3-(2 methylprop-1-enyl) cyclopropanecarboxylate 2% PBO 2%	1021-1687-8329	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, industrial, recreational areas, overgrown waste areas, athletic fields, woodlands, gardens, playgrounds, campsites, municipalities swamps, marshes, agricultural areas, etc.
AquaANVIL Water-based Adulticide	3-Phenoxybenzyl-(1RS, 3RS, 1RS, 3SR)-2,2-dimethyl-3-(2 methylprop-1-enyl) cyclopropanecarboxylate 10% PBO 10%	1021-1807-8329	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, industrial, recreational areas, overgrown waste areas, athletic fields, woodlands, gardens, playgrounds, campsites, municipalities swamps, marshes, agricultural areas, etc.
Aquahalt Water-Based Adulticide	Pyrethrins 5% PBO Technical 25%	1021-1803-8329	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, industrial, recreational areas, overgrown waste areas, athletic fields, woodlands, gardens, playgrounds, campsites, municipalities swamps, marshes, agricultural areas, etc.
Aqua-Kontrol Concentrate	Permethrin 20% PBO Technical 20%	73748-1	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, industrial, recreational areas, overgrown waste areas, athletic fields, woodlands, gardens, playgrounds, campsites, municipalities, etc.

Table 2-3 Adulticides Marin/Sonoma Mosquito and Vector Control District Uses for Mosquito Abatement

Pesticide Product Name	Common Name / Active Ingredients	CAS or EPA Number	Mode of Action	Timing of Application	Method of Application	Sites
Aqualuer 20-20	Permethrin 20.6% PBO Technical 20.6%	769-985	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, industrial, recreational areas, overgrown waste areas, athletic fields, woodlands, gardens, playgrounds, campsites, municipalities, agricultural areas, etc.
Aqua-Reslin	Permethrin 20% PBO Technical 20%	432-796	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, industrial, urban areas, parks, campsites, woodlands, athletic fields, golf courses, playgrounds, recreational, overgrown waste areas, roadsides, etc.
Biomist 4+12 ULV	Permethrin 4% PBO Technical 12%	8329-34	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV,	Residential and recreational areas
Biomist 4+4 ULV	Permethrin 4% PBO 4%	8329-35	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, industrial, recreational areas, overgrown waste areas, athletic fields, woodlands, gardens, playgrounds, campsites, municipalities, etc.
Duet Dual-Action Adulticide	Prallethrin 1% Sumithrin 5% PBO 5%	1021-1795-8329	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential and recreational areas, woodlands, parks, swamps, marshes, overgrown areas, golf courses, etc.
Evergreen Crop Protection EC 60-6	Pyrethrins 6% PBO Technical 60%	1021-1770	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, industrial, recreational and agricultural areas, swamps, marshes, overgrown waste areas, roadsides and pastures
Kontrol 2-2	Permethrin 2% PBO Technical 2%	73748-3	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, **Aerial	Residential, industrial, recreational areas, overgrown waste areas, athletic fields, woodlands, gardens, playgrounds, campsites, municipalities, etc.

Table 2-3 Adulticides Marin/Sonoma Mosquito and Vector Control District Uses for Mosquito Abatement

Pesticide Product Name	Common Name / Active Ingredients	CAS or EPA Number	Mode of Action	Timing of Application	Method of Application	Sites
Kontrol 30-30 concentrate	Permethrin 30% PBO Technical 30%	73748-5	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, industrial, recreational areas, overgrown waste areas, athletic fields, woodlands, gardens, playgrounds, campsites, municipalities, etc.
Kontrol 4-4	Permethrin 4.6% PBO Technical 4.6%	73748-4	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, industrial, recreational and agricultural areas, swamps, marshes, overgrown waste areas, roadsides and pastures, etc.
Permanone 31-66	Permethrin 31.28% PBO Technical 66%	432-1250	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, industrial, recreational and agricultural areas, swamps, marshes, overgrown waste areas, roadsides and pastures
Permanone RTU 4%	Permethrin 3.98% PBO Technical 8.48%	432-1277	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, ATV	Golf courses, parks, playgrounds, recreational areas, tire dumps, urban areas, etc.
Prentox Perm-X UL 4-4	Permethrin 4% PBO 4%	655-898	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, industrial, recreational and agricultural areas, swamps, marshes, overgrown waste areas, roadsides
Prentox Pyronyl Crop Spray	Pyrethrins 6% PBO Technical 60%	655-489	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, industrial, recreational and agricultural areas, swamps, marshes, overgrown waste areas, roadsides and pastures
Prentox Pyronyl Oil Concentrate #525	Pyrethrins 5% PBO Technical 25%	655-471	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, industrial, recreational and agricultural areas, swamps, marshes, overgrown waste areas, roadsides and pastures
Prentox Pyronyl Oil Concentrate or 3610A	Pyrethrins 3% PBO Technical 6%	655-501	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV	Industrial areas, urban areas, parks, campsites, woodlands, athletic fields, golf courses, playgrounds, recreational and overgrown waste areas, roadsides, and other public areas

Table 2-3 Adulticides Marin/Sonoma Mosquito and Vector Control District Uses for Mosquito Abatement

Pesticide Product Name	Common Name / Active Ingredients	CAS or EPA Number	Mode of Action	Timing of Application	Method of Application	Sites
Pyrenone 25-5 Public Health Insecticide	Pyrethrins 5% PBO 25%	432-1050	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Industrial areas, urban areas, parks, campsites, woodlands, athletic fields, golf courses, playgrounds, recreational and overgrown waste areas, roadsides, and other public areas
Pyrenone Crop Spray	Pyrethrins 6% PBO Technical 60%	432-1033	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, agricultural, swamps, marshes, roadsides, pastures, overgrown waste areas
Pyrocide Mosquito Adulticiding Concentrate for ULV Fogging 7395	Pyrethrins 12% PBO Technical 60%	1021-1570	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, agricultural, swamps, marshes, roadsides, pastures, overgrown waste areas
Pyrocide Mosquito Adulticiding Concentrate for ULV Fogging 7396	Pyrethrins 5% PBO Technical 25%	1021-1569	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, industrial, recreational and agricultural areas, swamps, marshes, overgrown waste areas, roadsides and pastures
Pyrocide Mosquito Adulticide 7453	Pyrethrins 5% PBO Technical 25%	1021-1803	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, industrial, recreational and agricultural areas, swamps, marshes, overgrown waste areas, roadsides and pastures, etc.
Scourge 18%***	Resmethrin 18% Piperonyl Butoxide 54%	432-667	Insect nervous system stimulation	January - December	Hand equipment, truck, boat, ATV, **Aerial	e.g., Industrial areas, urban areas, parks, campsites, woodlands, athletic fields, golf courses, playgrounds, recreational and overgrown waste areas, roadsides, etc.

Table 2-3 Adulticides Marin/Sonoma Mosquito and Vector Control District Uses for Mosquito Abatement

Pesticide Product Name	Common Name / Active Ingredients	CAS or EPA Number	Mode of Action	Timing of Application	Method of Application	Sites
Zenivex E4 RTU	Etofenprox 4%	2724-807	Insect nervous system stimulation	Jan.-Dec.	Hand equipment, truck, boat, ATV, *Aerial	Residential, industrial, recreational areas, overgrown waste areas, athletic fields, woodlands, gardens, playgrounds, campsites, municipalities, etc.

* Marin/Sonoma Mosquito and Vector Control District currently does not perform aerial adulticide applications. Aerial adulticide applications will be considered in an imminent health risk situation or a public health emergency (epidemic). Currently, approval by the District's Board of Trustees is required for aerial adulticide applications.

** The listed mosquito adulticides will be considered for use based on efficiency of application, efficacy, adult mosquito resistance issues, public health situations/emergencies, availability of mosquito adulticides in use, product rotation, cost, and environmental compatibility.

***Scourge pesticides to be replaced with Pyrenone 25-5 Public Health Insecticide, EPA Number 432-1050, once existing supplies are used up.

CAS Number = Chemical Abstracts Service Registry Number

EPA Number = Registered with the US Environmental Protection Agency

Using aerial application equipment has several advantages compared to ground application. It can be more economical for large target areas with extensive mosquito production. Large areas can be covered more quickly and it can free District staff to conduct other needed surveillance or control. Aerial application can be more practical for remote or inaccessible areas, such as islands, large marshes, and densely vegetated areas, than ground larviciding. However, potential for drift is greater with aerial applications, especially with liquid or ultralow volume (ULV) aerial larviciding and, consequently, more potential risk of nontarget exposure exists. In addition, accuracy in hitting the target area temporarily requires additional manpower for flagging or electronic guidance systems, which can increase costs. Finally, in addition to the timing constraints inherent in most larvicide use, the potential application window can be very narrow for aerial activities due to weather conditions.

2.3.5.1.2 Mosquito Adulticides

In addition to chemical control of mosquito larvae, the District may use adulticides for control of adult mosquitoes if necessary and if guidelines are met, including species composition, population density and abundance (as measured by landing count or other quantitative method), proximity to human populations, and/or human disease risk. As with larvicides, adulticides are applied in strict conformance with label requirements (Appendix B). Adulticides the District uses include Pyrethrins (Pyrocide®); and the synthetic pyrethroids Resmethrin (Scourge®) and Etofenprox. Table 2-3 lists the adulticides the District uses and may use for mosquito abatement for 2014 and beyond. Adulticide materials are used infrequently and only when necessary to control adult mosquito populations.

Ground Adulticiding Techniques

The most common form of adulticide application is via insecticide aerosols at very low dosages. This method is commonly referred to as the ultra low volume (ULV) method. This method employs specially designed ULV equipment mounted on trucks, ATVs, utility vehicles, watercraft, and with hand equipment for ground applications. Barrier or residual treatments for adult mosquitoes consist of an application using a material generally applied with a compressed air sprayer to the preferred foliage, buildings, or resting areas of the mosquito species. The District currently does not utilize barrier treatments.

Cold aerosol generators, cold foggers, and ULV aerosol machines were developed to eliminate the need for great quantities of petroleum oil diluents necessary for historical fogging techniques. These units are constructed by mounting a vortex nozzle on the forced air blower of a thermal fogger. Insecticide is applied as technical material or at moderately high concentrations (as is common with the pyrethroids), which translates to very small quantities per acre and is, therefore, referred to as ULV. In agriculture, this application rate is assumed less than 36 ounces per acre, but mosquito control ground adulticiding operations rarely exceed 1 ounce per acre. The optimum sized droplet for mosquito control with cold aerosols applied at ground level has been determined to be in the range of 10 to 30 microns.

Adulticiding is the only known effective measure of reducing an adult mosquito population in a timely manner. All mosquito adulticiding activities follow reasonable guidelines to avoid affecting nontarget species including bees. Timing of applications (when mosquitoes are most active), avoiding sensitive habitat areas, working and coordinating property owners and personnel of other agencies when required, and following label instructions all result in environmentally sound mosquito control practices.

Aerial Adulticiding Techniques

Aerial applications may be the only reliable means of obtaining effective control in areas bordered by extensive mosquito production sites or with a small, narrow, or inaccessible network of roads. Aerial adulticiding is often the only means available to cover a very large area quickly in case of severe mosquito outbreaks or vector-borne disease epidemics. At the time of publication, the District has never performed aerial adulticiding, but this technique could potentially be utilized in the future if absolutely

necessary to deal with a severe risk of disease transmission. As a matter of policy, aerial application of adulticide products would require the approval of the Board of Trustees.

Two aerial adulticiding techniques are used in California: low-volume spraying and ULV aerosols. Low-volume (<2-gallon-per-acre) sprays are applied with the pesticide diluted in light petroleum oils or water and applied as a rather wet spray. The size of the droplets reduces drift, thus limiting swath widths, and may not be ideal under certain circumstances for impinging on mosquitoes. The technique is compatible with equipment commonly used for aerial liquid larviciding.

A common aerial adulticiding technique applies the insecticide in a technical concentrate or in a very high concentration formulation as a ULV cold aerosol. Lighter aircraft, including helicopters, can be used because the insecticide load is a small fraction of the other techniques. If the aircraft are capable of speeds greater than 120 knots, fine droplets can be created by the high-speed air stream impacting the flow from hydraulic nozzles. Slower aircraft and most helicopters typically use some variety of rotary atomizers to create the required droplet spectrum. ULV applications can be difficult to accurately place with any regularity. Without the visual cues, drift and settling characteristics can be difficult to assess.

The flight parameters differ by program and technique. Some operations fly during hours of daylight so their applications begin either at morning's first light or before sunset and work into twilight. At these times, the pilots should be able to see towers and other obstructions as well as keep track of the material plume. The aircraft can be flown at less than a 200-foot altitude, which may make it easier to hit the target area.

Other operations may be conducted in the dark of the night, typically after twilight or early in the morning before dawn. The aircraft typically are flown at an altitude of between 200 and 300 feet. Swath widths vary from operation to operation but are normally set somewhere between 400 and 1,200 feet. Most mosquito flight activity is crepuscular, so these flights catch the adults at their peak activity.

Swaths are flown as close to perpendicular with the wind as is possible, working into the wind and commonly forming a long, tight S pattern. A number of factors affect the spray-drift offset and settling such as wind speed, droplet size, aircraft wake turbulence, altitude, and even characteristics of the individual aircraft. Pilots rely somewhat on experience for determining this offset, and some use telltale smoke or paper markers for swath alignment.

Aerial applications may be conducted over, but are not limited to, the following land uses within the Program Area: salt marsh, diked marsh, and seasonal wetlands; evaporation ponds and wastewater ponds; and agricultural, residential, commercial, industrial, and recreational areas. Urban or suburban areas would only be treated in the event of a severe risk of disease transmission and following approval of the Board of Trustees.

2.3.5.2 Yellow Jacket Wasp and Tick Abatement

Besides using insecticides for mosquito populations, the District selectively applies them to control ground-nesting yellow jackets that pose an imminent threat to people or to pets. This activity is generally triggered by public requests for District assistance or action rather than as a result of regular surveillance of their populations. The District excludes from its yellow jacket control program populations of this vector that are located in or on a structure. Yellowjacket nests that are off the ground would only be treated under special circumstances to protect public health and safety of the District's residents. Whenever a District technician learns that a nest is situated inside or on a structure or is above ground, the resident(s) are encouraged to contact a private pest control company that is licensed to perform this work. When a technician encounters a honeybee swarm or unwanted hive, residents are provided a list of beekeepers that can safely remove the bees. If a District technician deems it appropriate to treat yellow jackets, he or she will apply the insecticide directly within the nest in accordance with the District's policies and the product label to avoid drift of the insecticide or harm to other organisms.

Pyrethroid and Pyrethrin-based chemicals are typically used against ground-nesting yellow jackets and ticks. The potential environmental impacts of these materials are minimal due to two factors: (1) their active ingredients consist largely of Pyrethrin (a photosensitive natural insecticide manufactured from a Chrysanthemum species), or Allethrin and Phenothrin (first generation synthetic pyrethroids with similar photosensitive, nonpersistent characteristics as Pyrethrin), and (2) the mode of their application for yellow-jacket population control (i.e., directly into the underground nest) prevents drift and further reduces the potential for inadvertent exposure to these materials. The pesticides the District uses to control yellow jacket and tick populations are shown in Table 2-4 (Pesticides the District Uses for Yellowjacket Wasp and Tick Abatement). The District does not currently perform control work with respect to tick populations but may potentially do a limited amount of control work in the future in localized areas, such as adjacent to a trail where human contact is probable. The pesticides that may be considered in conjunction with tick control are shown in Table 2-4.

2.3.5.3 Rat Abatement

The District's rodent program is limited to site inspections and the provision of advice to property owners and tenants. No rodenticides are used by District staff.

2.3.6 Other Nonchemical Control/Trapping Alternative

The District may engage in trapping of rodents (including rats) and yellow jacket wasps in order to determine the presence of these vectors, conduct population surveys or secure vectors for pathogen/disease surveillance purposes. The District consults with resource agencies to acquire the appropriate permits when applicable, which may include a scientific collecting permit from CDFW which is required (CDFW code 711.2). Most often trapping of small mammals is coordinated with and performed in conjunction with CDPH who acquires the required permits. For live trapping usually of mice (*Peromyscus spp*.), blood samples are taken and mice are then released. This work is mostly for hantavirus testing. Anything captured is released. A report for captured and salvaged animals is filed with CDFW at the conclusion of each night/day of collecting. This would include any special status species encountered. The potential is very low that a special status species would be caught but the potential exists, even if extremely remote. A scientific collecting permit also is required for the salvage of dead birds for WNV testing, again usually coordinated with CDPH, although sometimes the District will obtain its own permit.

2.4 Public Education

Public education is a key component of the District's IVMP that is used to encourage and assist reduction and prevention of vector habitats on private and public property. While this component is a critical element of the District's Program, public education activities are categorically exempt from CEQA review (CEQA Guidelines Section 15322) based on a finding by the State Secretary of Resources that these activities do not have a significant effect on the environment. Therefore, these educational activities will not be further reviewed in this document.

Table 2-4 Insecticides Proposed for Use by the Marin/Sonoma Mosquito and Vector Control District for Yellow Jacket Wasp and Tick Abatement

Pesticide Product Name	Common Name / Active Ingredients	CAS or EPA Number	Mode of Action	Timing of Application	Method of Application	Sites
Insecticides Marin/Sonoma Mosquito and Vector Control District Uses for Yellow Jacket Wasp and Tick Abatement						
Drione Insecticide	Pyrethrin 1% PBO Technical 10% Amorphous Silica Gel 40%	EPA 432-992	Insect nervous system stimulation / dehydration	Jan.-Dec.	Hand/Hand Equipment	Indoor/Outdoor
Delta Dust Insecticide	Deltamethrin 0.05%	EPA 432-772	Insect nervous system stimulation	Jan.-Dec.	Hand/Hand Equipment	Indoor/Outdoor
Wasp Freeze	Trans allethrin 0.129% Phenothrin 0.120%	EPA 499-362	Insect nervous system stimulation	Jan.-Dec.	Hand/Hand Equipment	Outdoor
Insecticides Marin/Sonoma Mosquito and Vector Control District May Potentially Use for Yellow Jacket Wasp and Tick Abatement						
Onslaught Microencapsulated	Esfenvalerate (S)-cyano (3-phenoxyphenyl) methyl-(S)-4-chloro-alpha-(1-methylethyl) benzene acetate 6.4%	EPA 1021-1815	Sodium channel modulator	Jan.-Dec.	Hand/Hand Equipment	Indoor/Outdoor
Wasp – X	Etofenprox 0.5% Tetramethrin 0.2% PBO 1%	EPA 2724-786	Insect nervous system stimulation	Jan.-Dec.	Hand/Held Equipment	Indoor/Outdoor

CAS Number = Chemical Abstracts Service Registry Number

EPA Number = Registered with the US Environmental Protection Agency

An excellent mosquito/vector prevention program includes good public education and outreach as key components. The District's education program teaches the public how to recognize, prevent, and suppress mosquito/vector breeding on their property. This part of the project is accomplished through the distribution of brochures, fact sheets, newsletters, participation in local events and fairs, presentations to community organizations, newspaper and radio advertising, public service announcements, social media postings, District website postings, and contact with District staff in response to service requests. Such activities involve negligible use of office supplies, and any vehicle trips are covered by the estimated equipment usage under surveillance and other nonchemical control activities. Public education also includes a school program that teaches future adults to be responsible by preventing and/or eliminating vector breeding sources and educates their parents or guardians about District services and how they can reduce vector-human interaction. Where activities designed to prevent or eliminate vector breeding sources are consistent with the activities performed by the District under the Program alternatives, they may be covered sufficiently for environmental impact in this PEIR.

Educational activities also include making recommendations on specific property development and land and water management practices or proposals, in response to ongoing or proposed developments or management practices that may create sources of mosquitoes/vectors. To ensure that the District does not indirectly encourage environmental impacts without CEQA review, the District informs landowners and others who might modify the physical environment in response to educational programs that they have specific environmental obligations, including compliance with CEQA and permit requirements. The District is not a permitting agency and it is not responsible for implementing or approving the control recommendations on specific property development; therefore, property owners or developers are required to prepare and submit their own documents for projects, which may require CEQA review. See also Section 1.8 on future CEQA compliance following completion, certification, and approval of this PEIR.

2.5 Emergency Activities

In the event of emergency conditions, comprising an actual or imminent disease outbreak declared by the CDPH, the District's Program activities will temporarily vary from its routine operational tools through increases in scope or intensity of methods, and potentially through use of legal pesticides, in strict conformance with label requirements, that the District does not routinely use. Because of their temporary nature and their similarity to routine activities, emergency activities are not evaluated separately in this PEIR. Emergency conditions are not reasonably foreseeable at this time, and any attempted environmental review of such undefined activities for an imminent disease outbreak would be inherently speculative. In addition, the state has recognized that emergency conditions may require prompt action of a nature or intensity above typical levels as a means to protect public health, welfare, safety, or property, and has exempted these activities from requirements for further environmental review (CEQA Guidelines Sections 15269, 15359).

2.6 Vehicles and Equipment Used to implement the Program

Equipment listed and described herein are those mechanized items with engines or applicators that have the potential to affect air quality, greenhouse gas emissions, noise, or hazard evaluations for the environmental impact analyses. The specific types of District vehicles and equipment, and aerial equipment used by other pesticide applicators under contract, used in its Program are listed in Table 2-5 (District Vehicle and Equipment List) and are the basis for the analyses of air quality, GHGs, and noise. The list includes vehicles, vehicle-borne pesticide applicators, personnel-borne applicators, and power tools. Nonmechanized equipment, such as trailers and hand rakes, are not included.

Table 2-5 Marin/Sonoma Mosquito & Vector Control District Vehicles and Equipment

Type of Vehicle/Equipment	Engine	Fuel Type
Ground Surveillance and Applications/Management		
John Deere Tractor	41.5 cubic inches: output 43.7 hp	Diesel
Chevy 3500 truck	454 cu in	Gasoline
Pistenbully PB100 (off road)	242.3 cubic inches: 170 hp	Diesel
Pistenbully Mower 72F-H (off road)	n/a	
Ford F-250 truck	Varied 5.4 liter to 6.2 liter	Gasoline
Ford F-250 truck 4x4	Varied 5.4 liter to 6.2 liter	Gasoline
Ford F-150 truck 4x4	4.6 liter	Gasoline
Ford F-350 truck	460 cu in	Gasoline
Ford Ranger truck 2x4	3.0 liter	Gasoline
Ford Ranger truck 4x4	3.0 liter	Gasoline
Ford F-550 4x4	6.0 liter	Diesel
Intelli Truck 3500	5.7 liter	Gasoline
Chevy HD 2500 truck	6.0 liter	Gasoline
Chevy W4500	6.0 liter	Gasoline
Ford Explorer	4.0 liter	Gasoline
Ford Explorer 4x4	4.0 liter	Gasoline
Ford E-150 Van	4.2 liter	Gasoline
Dump Truck 5 ton	390 cu in	Gasoline
Chevy Traverse	3.6 liter	Gasoline
Toyota Prius HB Three	1.8 liter hybrid	Gasoline
Argo Avenger (off road)	41.1 cubic inches 26 hp	Gasoline
Argo Conquest (off road)	37.8 cubic inches 21 hp	Gasoline
Arctic Cat 500 TBX (off road)	30.5 cubic inches 31 hp	Gasoline
Kawasaki 400 (off road)	23.8 cubic inches 26.5 hp	Gasoline
Kawasaki 650 (off road)	36.8 cubic inches 42 hp	Gasoline
Spryte (off road)	300 cubic inches 132 hp	Gasoline
Dondi Rotary Ditcher DMR 35-B	N/A	
GO-4 Catch Basin Rig	60.9 cubic inches 55 hp	Gasoline
GO-4 Spray tank	Electric 12v	
40 foot portable lift (Ameriquip)	Electric (battery operated)	Electric
Komatsu (off road)	Komatsu 3D94-2 35 hp	Diesel
Gator (off road)	37.7 cubic inches 18 hp	Gasoline
Trailer for Airboat	n/a	
Boat trailer	n/a	

Table 2-5 Marin/Sonoma Mosquito & Vector Control District Vehicles and Equipment

Type of Vehicle/Equipment	Engine	Fuel Type
7 x 14 Flatbed trailer	n/a	
6 x 10 trailer	n/a	
6 x 12 GO-4 trailer	n/a	
5 x 8 trailer	n/a	
Tilt trailer	n/a	
Lite Foot trailer	n/a	
Suzuki trailer	n/a	
Spryte/Komatsu trailer	n/a	
Lite Foot Snow Cat	1.3 liter 90 hp	Gasoline
Lite Foot Sprayer	hydraulic	
Nifty-Fifty	5.5 cu in 3 hp	Gasoline
Nifty-Fifty with Intelli reel	5.5 cu in 3 hp	Gasoline
Spryte tank	n/a	
Bike Sprayer	Electric 12v	
Hand fogger	3.0 cu in	2 stroke Gasoline
Backpack fogger (Colt)	3.0 cu in	2 stroke Gasoline
Backpack fogger (Curtis Dynaflow)	40 cc	2 stroke Gasoline
Becomist Fogger	Electric 12v	
Electramist fogger	Electric 12v	
Micro Gen hand fogger	3.0 cu in	Gasoline
Mozzie Fog Fogger	10.1 cu in 5.5 hp	Gasoline
Mozzie granular applicator	Electric 12v	
Old Suzuki tank	Electric 12v	
30-gallon sprayer	Electric 12v	
50-gallon sprayer	Electric 12v	
Argo seeder	Electric 12v	
Horn seeder	n/a	
Spryte seeder	19.4 cu in	Gasoline
Bike seeder	Electric 12v	
Kelly seeder	n/a	
Solo MD 150 DX	40.2 cc	2 stroke Gasoline
Solo MD 155 DX	40.2 cc	2 stroke Gasoline
High Pressure sprayer	41.9 cu in 21 hp	Gasoline
12v Argo tank	Electric 12v	
12v Spray tank for bike	Electric 12v	

Table 2-5 Marin/Sonoma Mosquito & Vector Control District Vehicles and Equipment

Type of Vehicle/Equipment	Engine	Fuel Type
Faye Mosquito Trap	n/a	
EVS Mosquito Trap	Electric 6v	
New Jersey Light Mosquito Trap	Electric 110v	
Chicken coops for sentinel chickens	n/a	
1 gal back can sprayer	n/a	
3 gal back can sprayer	n/a	
Yellowjacket Duster	n/a	
Echo hand held blower	17 cc	2 stroke Gasoline
Echo backpack blower	40.2 cc	2 stroke Gasoline
Echo Chainsaw	30.1 cc	2 stroke Gasoline
Echo hedge trimmer	21.2 cc	2 stroke Gasoline
Husqvarna Weedeater	21.7 cc	2 stroke Gasoline
Husqvarna Chainsaw	55.5 cc	2 stroke Gasoline
Intelli sprayer 150	14.8 cu in 9 hp	Gasoline
Intelli sprayer 50	14.8 cu in 9 hp	Gasoline
Agnique spray bottle	n/a	
2500 Gal Water Truck 01 Int 8000 (Operated by Alpine Helicopter – Contractor) GW 52,000 lbs	10.3 liter	Diesel
2000 Gal Water truck 99 Int 4700 (Operated by Alpine Helicopter – Contractor) GW 33,000 lbs	7.6 liter	Diesel
2000 Gal Water truck 97 Ford Louisville (Operated by Alpine Helicopter – Contractor) GW 33,000 lbs	7.9 liter	Diesel
99 Ford F550 Flat Bed 4X4 truck	7.3 liter	Diesel
05 Dodge 2500 4X4 truck	5.9 liter	Diesel
Big Mix Trailer 800 Gal Tank	n/a	
Ball Mix Trailer 1000 Gal Tank	n/a	
Water Surveillance and Applications/Management		
Airboat	502 cubic inches: output 502 hp	Gasoline
Airboat spray tank	7.4 cu in	Gasoline
Grizzly 17 ft. Boat	60.8 cu in	Gasoline
Klamath Boat	100 cc 9.9 hp	2 stroke Gasoline
Flat bottom boat	123 cc 4 hp	Gasoline
Boat trailer	n/a	
Pistenbully PB100 (off road)	242.3 cubic inches: 170 hp	Diesel
Pistenbully Mower 72F-H (off road)	n/a	
Argo Avenger (off road)	41.1 cubic inches 26 hp	Gasoline

Table 2-5 Marin/Sonoma Mosquito & Vector Control District Vehicles and Equipment

Type of Vehicle/Equipment	Engine	Fuel Type
Argo Conquest (off road)	37.8 cubic inches 21 hp	Gasoline
Spryte (off road)	300 cubic inches 132 hp	Gasoline
Dondi Rotary Ditcher DMR 35-B	N/A	
Komatsu (off road)	Komatsu 3D94-2 35 hp	Diesel
Nifty-Fifty with Intelli reel	5.5 cu in 3 hp	Gasoline
Bike Sprayer	Electric 12v	
Mozzie granular applicator	Electric 12v	
30-gallon sprayer	Electric 12v	
50-gallon sprayer	Electric 12v	
Solo MD 150 DX	40.2 cc	2 stroke Gasoline
Solo MD 155 DX	40.2 cc	2 stroke Gasoline
High Pressure sprayer	41.9 cu in 21 hp	Gasoline
12v Argo tank	Electric 12v	
12v Spray tank for bike	Electric 12v	
1 gal back can sprayer	n/a	
3 gal back can sprayer	n/a	
Intelli sprayer 150	14.8 cu in 9 hp	Gasoline
Intelli sprayer 50	14.8 cu in 9 hp	Gasoline
Agnique spray bottle	n/a	
Aerial Applications		
1968 Bell 206 Jet Ranger helicopter (Operated by Alpine Helicopter – Contractor) 120 gal material tank	Allison 250-C20J turboshaft, 420 shp	Jet fuel
1989 Bell 206 Jet Ranger helicopter (Operated by Alpine Helicopter – Contractor) 120 gal material tank	Allison 250-C20J turboshaft, 420 shp	Jet fuel
1960 Hiller Soloy helicopter (Operated by Alpine Helicopter – Contractor) 120 gal material tank	Allison 250-C20J turboshaft, 420 shp	Jet fuel
Isolair Air spray system model 3900 (helicopter-mounted)	n/a	
Isolair 4400 bucket system (helicopter-mounted)	n/a	
Isolair 4500 broadcaster (helicopter-mounted)	n/a	

2.6.1 Vehicles and Equipment for Ground Surveillance, Vegetation Management, and Chemical Application

The District uses pickup trucks that have been suitably modified for the particular Program activity. Generally, a chemical container tank, high-pressure, low-volume electric or gas pump, and spray nozzle are mounted in the back of the bed, with a switch and extension hose allowing the driver and/ or assistant to operate the equipment and apply larvicides or adulticides from the truck's cab or by utilizing hoses deployed from the bed of the truck to apply larvicides. When treatment sites cannot be accessed by roads, access is by way of ATVs or by foot (if vehicle access is prohibited), and treatments are made using handheld sprayers/applicators or ATV mounted application equipment or belly grinders (for granular or pellet formulations). Some situations where flooding and wetlands preclude access by 4-wheel drive vehicles or reasonable walking distance in waders/boots do require the use of an approved ATV. District staff does not use ATVs where environmental conditions (e.g., impenetrable vegetation/terrain, endangered/threatened plants, sensitive habitat) can result in causing an accident, personal injury, or significant environmental damage. When used, ATVs are fitted with a chemical container mounted on the vehicle, a 12-volt electric- or gasoline-engine-powered pump supplying high-pressure, low-volume flow, and a hose and spray tip allowing for application while steering the vehicle. Application equipment designed to apply granular larvicides are also used on ATVs. ATVs are ideal for treating areas like agricultural fields, pastures, salt marshes, and other offroad sites.

Additional equipment used in ground applications includes handheld sprayers, seeders, and backpack sprayers/blowers. Handheld sprayers (handcans) are standard 1- or 2- or 2- or 3-gallon garden style pump-up sprayers used to treat small isolated areas with precision. Backpack sprayers are either gas or hand powered and are fitted with chemical tanks that can hold granular or pellet formulations in addition to liquid. Generally, for smaller areas, pellet or small granular material is applied with a mechanical hand-crank spreader, seeder, or backpack blower.

The manual removal of vegetation is the primary method of vegetation removal within or around a water body and would be performed using hand pruners, trimmers, handsaws, chainsaws, and weed eaters. The use of heavy equipment for vegetation management in waterways supporting native or special-status fish species would only be used with the following BMPs: not operating such equipment in the water; providing appropriate containment and cleanup systems to avoid, contain, and cleaning up any leakage of toxic chemicals into the aquatic environment; controlling turbidity; and minimizing the area that is affected by the vegetation management activity. The District contacts regulatory agencies and acquires applicable permits as appropriate. In Section 2.9, see Table 2-6 for a complete listing of BMPs used by the District at present and in the future.

2.6.2 Boats for Water Surveillance and Application

District personnel uses outboard-equipped boats and an automotive engine powered airboat to inspect and treat large water bodies and islands. They are commonly used for lakes, diked agricultural lands, seasonal wetlands, ponds, sewage treatment facilities etc. The boat provides the best access to inspect and treat the aquatic plant mats, algae mats, and islands for mosquitoes. Boat use minimizes vehicle travel in offroad areas of the creek beds and hazardous terrain along shorelines for carrying treatment equipment on foot. The airboat can be used specifically in areas with shallow water and vegetation that can preclude the use of an outboard boat or ATV, and provide increased efficiency and efficacy for surveillance and treatment in large aquatic areas. Further, boat operations do not have lasting environmental impacts.

2.6.3 Aerial Application

The District uses a contract agricultural application service to provide helicopter treatments to large or problematic/difficult access source areas (from approximately 20 to 600 acres, the smaller acreage sites are typically problematic and contain dense and abundant vegetation) and to especially problematic

sources of mosquito production. Helicopter and fixed-wing operations are done at very low altitude. The advantage of using a helicopter is the high efficiency of application to large areas without contact with the ground surface at a reasonable per acre cost. A helicopter can treat up to approximately 200 acres per hour. Helicopter treatments occur during daylight hours, typically 50 feet above the surface of the site being treated. A 120-gallon tank is used with a typical application rate of 2 gallons of final mix per acre. Although very costly, the application rate can exceed 5 gallons per acre (to as much as 10 to 100 gallons per acre) in "special" circumstances when a larger droplet size is desired to further minimize potential drift issues or to increase penetration of vegetative canopy in problematic situations. Typically, aerial larvicide treatments are performed using granular Bs and Bti formulations at a target rate of 10 to 20 pounds per acre and methoprene formulations at 2.5 to 10 pounds per acre depending on the density of vegetation. If dense vegetation is present, application rates of up to 20 pounds (for Bti, Bs) and 10 pounds per acre (methoprene) may be necessary.

The District does not currently use any fixed-wing aircraft for aerial treatments but could do so if the need arose.

2.7 Program Alternatives

The District has developed a range of project alternatives partially as result of input from the scoping process, and these alternatives and others are briefly described and evaluated in a technical report to the PEIR (Appendix E, *Alternatives Analysis Report*) and in Chapter 15. This technical report prepared by the District is also summarized in Chapter 15 of this PEIR.

2.7.1 No Program Alternative

CEQA Guidelines require an analysis of the "No Project" Alternative, which is defined as what would be reasonably expected to occur in the foreseeable future if the project were not approved, based on current plans and consistent with available infrastructure and community services [Section 15126.6, Subdivision (e)(2)]. For Program purposes, the No Program Alternative would be equivalent to "no action" or to discontinue the Program described above. In the absence of continuing the current Program, the District would not exist solely to engage in public education activities. See Section 15.3 for more information on the No Program Alternative.

The No Program Alternative would result in mosquito production in exponential proportions in many areas of the Program Area. Two mosquito species in particular, *Aedes squamiger and Aedes dorsalis* (i.e., salt marsh mosquitoes), for which the District was formed in 1915, can fly in excess of 20 miles from the water source. These species would impact a substantial number of communities in Marin, Sonoma, and neighboring counties, cause severe discomfort and potential injury to residents, and likely result in substantial vector issues concerning wildlife and livestock. Of the approximately 22 species of mosquitoes currently known to be present in Marin and Sonoma counties, several are known vectors of pathogens including West Nile virus, Western equine encephalitis, and St. Louis encephalitis. Organized, countywide surveillance and control by licensed and trained individuals for exotic and invasive mosquitoes species (i.e., Yellow fever mosquito - *Aedes aegypti* and Asian tiger mosquito - *Aedes* albopictus), that were recently discovered in nearby counties, and the pathogens they transmit (e.g., yellow fever, dengue fever, Chikungunya virus) would likely not be available. These exotic mosquitoes and their pathogens could spread throughout both counties.

2.7.2 Alternatives Eliminated from Further Consideration

These alternatives are identified and evaluated in the District's *Alternatives Analysis Report* (Appendix E) and summarized in Section 15.2 of this PEIR. They include the following:

> Biological Control pathogens (viruses) is deemed infeasible as this method is not commercially available in California, and there are currently many efficacy related issues.

> Biological Control (parasites) is deemed infeasible as this method is not commercially available in California. Research on the use of parasites for mosquito control has also shown several limitations related to efficacy.

> Mass Trapping is not considered by the District to be a practical, effective, reliable method of controlling vector populations. Can be very expensive and time consuming (i.e., labor intensive).

> Attract and Kill is not considered by the District to be a practical, effective, reliable, method of controlling vector populations. The technology for both mosquitoes and yellow jackets is limited, and effectiveness is either not obtained or is inconsistent. Nontarget insects can be impacted.The District is aware of one commercially available ATSB product, Terminix® AllClear. The District still needs to operationally test this material, as well as other potential ATSBs, to determine those circumstances where their use may be effective while also having little or no nontarget species impacts.

> Inundative Releases of parasites is not considered by the District to be a practical or currently feasible method of controlling vector populations. They are not commercially available and remain experimental at this time.

> Inundative Releases of predators, either sterilized or genetically altered organisms, is not considered by the District to be a practical or a currently feasible method of controlling vector populations. Genetically modified vectors are still experimental. They are also not commercially available at this time.

> Regulatory Control is not considered feasible because adoption of regulations is lengthy, time intensive, expensive and uncertain as to the regulatory outcome. This approach is not focused sufficiently on control of existing populations. Moreover, regulatory controls are dependent upon state and federal agencies to initiate and implement, and thus this approach cannot assure that any Program objectives would be achieved.

> Repellants, although effective for small-scale use by humans and animals, are not part of the overall Program control strategy because they merely displace the problem and do not reduce the mosquito population in an area.

2.7.3 Other Program Alternatives

While no other alternatives are considered feasible or appropriate to achieve the District's Program objectives, and all of the Program alternatives would be combined into the District's Proposed Program, potential options or alternative methods within some of the Program alternatives could be used to modify those alternatives, thus minimizing impacts to the environment or replacing chemical treatments previously used.

One potentially significant impact is associated with the Proposed Program, an air quality impact associated with the Chemical Control Alternative. The Chemical Control Alternative could subject people to objectionable odors. Impacts even with BMPs implemented could be **potentially significant but mitigable** (Impact AQ-25)**.** Certain VOCs, sulfur compounds, and chlorine compounds found in some pesticides emit characteristic odors when they evaporate (volatilize) into air, even at very low concentrations well within safety limits. Pesticides currently used or proposed for future use emit phenols (e.g., deltamethrin, etofenprox, permethrin, or resmethrin). Materials such as Bti in liquid form and the adulticides pyrethrin and permethrin have an odor.

To avoid the potentially significant impact associated with the Proposed Program, modifications to the Proposed Program could include the following:

> Reduced Program based on a Reduced Chemical Control Alternative

> Reduced Program with a No Chemical Control Alternative

These two alternative Programs are evaluated in Section 15.4. Limiting the choices of materials that can be used to a few chemicals significantly increases the risks of vector resistance to the few products that are available for use and, therefore, resulting in ineffective vector control. Removing the types of pesticides listed above from the IVMP entirely would reduce Program effectiveness and not meet Program objectives stated in Section 2.2.2. A No Chemical Control Alternative based Program would not be effective and not meet the District's Proposed Program objectives either. The No Chemical Control Alternative Program would not meet the principles of successful IVM. The impacts to public health would be substantial. Sound IVM involves many tools, with many materials being used, and using the most effective and least environmentally harmful products.

2.7.4 Environmentally Superior Alternative

Table S-1 presents a summary of all the impacts associated with each Program alternative and. therefore, the overall Proposed Program of all of the alternatives combined. It is based on Table 15-1 which presents a summary of all the statements of impact with significance determinations. For Surveillance, Physical Control, Vegetation Management, Chemical Control, and Nonchemical Control/Trapping Alternatives, the impacts are either "less than significant" (LS) or "no impact" (N).

There is only one potentially significant impact: The Chemical Control Alternative could subject people to objectionable odors. Impacts even with BMPs implemented could be **potentially significant but mitigable.** Certain VOCs, sulfur compounds, and chlorine compounds found in some pesticides emit characteristic odors when they evaporate (volatilize) into air, even at very low concentrations well within safety limits. Pesticides currently used or proposed for future emit phenols (e.g., deltamethrin, etofenprox, permethrin, or resmethrin). Materials such as Bti in liquid form and the adulticides pyrethrin and permethrin have an odor. Due to limited applicability, small quantities of these types of substances are typically used. The human sense of smell (olfactory system) is sensitive to these types of compounds as a warning mechanism, and some individuals are more sensitive than others. The Chemical Control Alternative would apply certain types of odorous treatments using hydraulic spraying and atomizing (fogging), which could result in drift of small droplets and gaseous vapors. Depending on atmospheric conditions (i.e., wind direction, wind speed, stability class), this drift could subject people to objectionable odors near a treatment area. The materials have been used in the current Program, and people have not complained about odors. However, it is possible that complaints could occur in the future despite public notification procedures about large-scale treatments.

Section 15.4 describes two "Reduced Program Alternatives:" Reduced Chemical Control and No Chemical Control.

> Reduced Chemical Control: To the extent the District can modify elements of the Chemical Control Alternative to mitigate identified impacts by avoiding the potentially significant impacts associated with some pesticide products by using less of these products or by eliminating them in favor of other, less odorous products, then the **environmentally superior alternative would be a Program incorporating these modifications to this alternative as components of the overall IVMP as long as Program effectiveness is maintained.** Excluding air quality and the odor issue, the impacts to all of the other resources would be the same as for the Proposed Program.

> No Chemical Control: This alternative would completely remove the chemical treatment options under the Vegetation Management and Chemical Control Alternatives. It would not have any of the less-than-significant impacts associated with herbicide and pesticide use. However, it was determined to be inconsistent with Program objectives and IVM principles, and it could lead to substantial impacts to human health due to the reduced effectiveness of the Program in controlling mosquito and other vector populations.

The No Program Alternative is not the environmentally superior alternative due to its potentially significant impacts to the following resources and concerns identified in Section 15.3: urban and rural land uses, aquatic and terrestrial biological resources, ecological health, human health, and public services and hazard response.

2.8 Other Required Permits and Agency Coordination

2.8.1 Required Permits

2.8.1.1 California Department of Public Health

The District's Program as a whole, including the registration and continuing education of state-certified field personnel, is reviewed and approved by the CDPH, through a formal Cooperative Agreement that is renewed annually. The CDPH also performs onsite annual inspection of the District's equipment, operations, safety training, and records.

2.8.1.2 Statewide General NPDES Permit for Vector Control

The application of pesticides at, near, or over waters of the US that results in discharges of pollutants requires coverage under a National Pollutant Discharge Elimination System (NPDES) permit. In response to the Sixth Circuit Court's decisions and previous decisions by other courts on pesticide regulation, the SWRCB has adopted four Pesticide Permits. Water Quality Order No. 2011-0002-DWQ (General Permit No. CAG 990004) is the Permit for Biological and Residual Pesticide Discharges to waters of the US from vector control applications. The District completed application requirements, including preparation of a Pesticide Application Plan (PAP) and public notice requirements, and received permit approval on October 31, 2011 (SWRCB 2011).

This General Permit covers the point source discharge of biological and residual pesticides resulting from direct to water and spray applications for vector control using (1) larvicides containing monomolecular films, methoprene, Bti, Bs), tempos, petroleum distillates, or spinosa; and (2) adulticides containing malathion, naled, pyrethrin, permethrin, resmethrin, sumithrin, prallethrin, PBO (an inert ingredient), etofenprox, or N-octyl bicycloheptene dicarboximide (or MGK-264). Users of products containing these active ingredients (and the inert PBO) are required to obtain coverage under this General Permit prior to application to waters of the US. This General Permit only covers the discharge of larvicides and adulticides that are currently registered in California.

Pursuant to California Water Code Section 13389, SWRCB and RWQCBs are exempt from the requirement to comply with Public Resources Code, Chapter 3, Division 13 when adopting NPDES permits (SWRCB 2011).

2.8.1.3 Statewide General NPDES Permit for Algae and Aquatic Weed Control

This General Permit regulates the discharge of aquatic pesticides (algaecides and aquatic herbicides) used for algae and aquatic weed control to waters of the United States. These are algaecides and aquatic herbicides with registration labels that explicitly allow direct application to water bodies. This General Permit became effective on December 1, 2013.

Except for discharges on tribal lands that are regulated by a federal permit, this General Permit covers the point source discharge to waters of the United States of residues resulting from pesticide applications using products containing 2,4-D, acrolein, copper, diquat, endothall, fluridone, glyphosate, imazamox, imazapyr, penoxsulam, sodium carbonate peroxyhydrate, and triclopyr-based algaecides and aquatic herbicides, and adjuvants containing ingredients represented by the surrogate nonylphenol. This General Permit covers only discharges of algaecides, and aquatic herbicides that are currently registered for use in California, or that become registered for use and contain the above-listed active ingredients and ingredients represented by the surrogate of nonylphenol.

A Discharger under this General Permit includes any entity involved in the application of algaecides and aquatic herbicides that results in a discharge of algaecides and aquatic herbicides and their residues and degradation byproducts to waters of the United States, and meets either or both of the following two criteria:

> The entity has control over the financing for or the decision to perform algaecide and aquatic herbicide applications that result in discharges, including the ability to modify those decisions; or

> The entity has day-to-day control of algaecide and aquatic herbicide applications or performs activities that are necessary to ensure compliance with this General Permit. For example, the entity is authorized to direct workers to carry out activities required by this General Permit or perform such activities themselves.

2.8.1.4 United States Army Corps of Engineers

For minor physical control activities, the District obtains 5-year regional permits from the USACE, the SWQCB, and from the BCDC (with review by the USFWS, CDFW, NMFS and other agencies as needed). The current USACE permit runs through February 1, 2013, and the BCDC permit runs through April 1, 2014. The District is currently working collaboratively with the CDPH and other Coastal Region Districts toward renewing the USACE source reduction permit.

2.8.1.5 United States Fish and Wildlife Service

The District is required to submit an annual Pesticide Use Proposal (PUP) and apply for a Supplemental Use Permit (SUP) whenever performing vector control activities on USFWS lands. Depending on the location and nature of the work, the District may also be required to consult with the USFWS under Section 7 of the federal Endangered Species Act to address potential impacts to special status species and their habitats. In addition to SUPs and PUPs, the USFWS reviews and may also comment on the District's proposed annual minor physical control projects (see Section 2.8.1.4 above on the USACE permit).

2.8.1.6 County Agricultural Commissioner

County Agricultural Commissioners also regulate sale and use of pesticides in California. In addition, County Agricultural Commissioners issue Use Permits for applications of pesticides that are deemed as restricted materials by CDPR. For chemical control activities, the District reports to and is periodically reviewed by the County Agricultural Commissioners for Marin and Sonoma Counties. The District's Use Permit was issued by the County of Sonoma on October 3, 2012 and by the County of Marin on March 10, 2014.

During the permitting process, County Agricultural Commissioners determine if the pesticide use will result in substantial adverse environmental impact, whether appropriate alternatives were considered, and if any potential adverse effects are mitigated. The Use Permit conditions contain minimum measures necessary to protect people and the environment. The County Agricultural Commissioners may choose to rely on this PEIR in making their determination.

2.8.2 Agency Coordination

For work on State of California lands and riparian zones, wetlands, or other sensitive habitats, the District coordinates, reviews activities, communicates, and often collaborates with several agencies including the USFWS, CDFW, Marin and Sonoma County agencies, municipalities, and property owners of Marin and Sonoma counties. District staff has had long standing and continues to have cooperative, collaborative relationships with federal, state, and local agencies. The District regularly communicates with agencies regarding the District's operations and/or the necessity and opportunity for increased access for surveillance, source reduction, habitat enhancement, and the presence of special-status species and wildlife. The District often participates in and contributes to interagency projects. The District will continue to foster these relationships, communication, and collaboration. In particular, District staff will regularly communicate with resource agency staff regarding vector management operations, habitat, and flora and

fauna in sensitive habitats. Such communications will include wildlife studies and occurrences of sensitive species in areas that may be subject to vector management activities.

For operations that generate noise expected to be of concern to the public, the following measures will be implemented:

> Measure 1: Provide Advance Notices: A variety of measures are implemented depending on the magnitude/nature of the activities undertaken by the District, and may include but are not limited to press releases, social media, District websites, e-mails, phone messages, hand delivered flyers, and posted signs. Public agencies and elected officials also may be notified of the nature and duration of the activities, including the Board of Supervisors or City Council, environmental health and agricultural agencies, emergency service providers, and airports.

> Measure 2: Provide Mechanism to Address Complaints: District staff is available during regular business hours to respond to service calls and address concerns about nighttime operations.

2.9 Best Management Practices

The District has implemented a number of procedures and practices under current Program activities that would continue into the future for the Proposed Program. These BMPs represent measures to avoid, minimize, eliminate, rectify, or compensate for potential adverse effects on the human, biological, and physical environments and District Staff. While similar to mitigation measures under CEQA, these BMPs are already in use and would continue to be used as part of the Proposed Program. Subsequent environmental impact assessments in this PEIR reflect the continued use of these measures, which are organized under the following categories and listed in Table 2-6:

> General BMPs

> Tidal Marsh-Specific BMPs

> Salt Marsh Harvest Mouse (SMHM)

> Ridgway's Rail (RIRA)

> Soft Bird's Beak (SBB)

> Vegetation Management

> Maintenance/Construction and Repair of Tide Gates and Water Structures in Waters of the U.S.

> Applications of Pesticides, Surfactants, and/or Herbicides

> Hazardous Materials and Spill Management

> Worker Illness and Injury Prevention Program and Emergency Response.

The Districts will observe all state and federal regulations. The Districts will follow all appropriate laws and regulations pertaining to the use of pesticides and herbicides and safety standards for employees and the public, as governed by the USEPA, CDPR, and local jurisdictions (with some exceptions). Although the products the District uses are all tested, registered, and approved for use by the USEPA and/or CDPR, Districts provide additional margins of safety with the adherence to additional internal guidance based on BMPs and the principles embodied in District IVMP policies, where applicable.

> Ensure all District and contracted applicators are appropriately licensed by the state.

> District staff or contractors will coordinate with the County Agricultural Commissioners, and obtain and verify all required licenses and permits as current prior to pesticide/herbicide application.

> All applicators and handlers will use proper personal protective equipment.

2.9.1 Pesticide Applications to Product Label Requirements

2.9.1.1 California Pesticide Regulatory Program

CDPR regulates the sale and use of pesticides in California. CDPR is responsible for reviewing the toxic effects of pesticide formulations and determining whether a pesticide is suitable for use in California through a registration process. Although CDPR cannot require manufacturers to make changes in labels, it can refuse to register products in California unless manufacturers address unmitigated hazards by amending the pesticide label. Consequently, many pesticide labels that are already approved by USEPA also contain California-specific requirements. Pesticide labels defining the registered applications and uses of a chemical are mandated by USEPA as a condition of registration. The label includes instructions telling users how to make sure the product is applied only to intended target pests and includes precautions the applicator should take to protect human health and the environment. For example, product labels may contain such measures as restrictions for applications in certain land uses and weather (i.e., wind speed) parameters.

2.9.2 Other BMPs for Mosquito and/or Vector Control

Many BMPs the District directly practices can be found in the *Best Management Practices for Mosquito Control in California* (CDPH and MVCAC 2012). These BMPS are incorporated by reference into this PEIR and are reproduced in their entirety in Appendix F, *Supplemental Program Information*.

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Table 2-6 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid/Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Surveillance	Physical Control	Veg Mgmt	Bio Control	Chemical Control	Other
A. General BMPs						
1. District staff has had long standing and continues to have cooperative, collaborative relationships with federal, state, and local agencies. The District regularly communicates with agencies regarding the District's operations and/or the necessity and opportunity for increased access for surveillance, source reduction, habitat enhancement, and the presence of special status species and wildlife. The District often participates in and contributes to interagency projects. The District will continue to foster these relationships, communication, and collaboration.	√	√	√	√	√	√
2. In particular, District staff will regularly communicate with resource agency staff regarding vector management operations, habitat, and flora and fauna in sensitive habitats. Such communications will include wildlife studies and occurrences of sensitive species in areas that may be subject to vector management activities.	√	√	√	√	√	√
3. When walking or using small equipment in marshes, riparian corridors, or other sensitive habitats, existing trails, levees and access roads will be used whenever possible to minimize or avoid impacts to species of concern and sensitive habitats. Specific care will be taken when walking and performing surveillance in the vicinity of natural and manmade ditches or sloughs or in the vicinity of tidal marsh habitat.	√	√	√	*[4]	√	√
4. District staff has received training from USFWS and CDFW biologists regarding endangered species, endangered species habitat, and wildlife/wildlife habitat recognition and avoidance measures. District supervisory staff frequently engages staff on these subjects. For example, District staff has become familiar with Ridgway's rail call recordings to invoke avoidance measures if these calls are heard in the field. District staff is trained to be observant, proceed carefully, and practice avoidance measures if needed when accessing areas that may serve as bird nesting habitat (e.g., watch for flushing birds that may indicate a nest is nearby). Emphasis will be placed on species and habitats of concern where vector management activities might occur (e.g., SMHM, RIRA, special-status plants, vernal pools, tidal marsh, etc.). These training sessions will be included as a part of the safety training records that are kept by vector control agencies.	√	√	√		√	√

[4] *means not available at this time. Should a viable biocontrol agent become available, evaluation of BMP measures would occur and be implemented.

Best Management Practice (BMP)	Surveillance	Physical Control	Veg Mgmt	Bio Control	Chemical Control	Other
5. Conduct worker environmental awareness training for all treatment field crews and contractors for special status species and sensitive natural communities that a qualified person (e.g., District biologist) determines to have the potential to occur on treatment sites. Conduct the education training prior to starting work at treatment sites and upon the arrival of any new worker onto sites with the potential for special status species or sensitive natural communities.	√	√	√	√	√	√
6. District staff will work with care and caution to minimize potential disturbance to wildlife while performing surveillance and vector treatment/population management activities (see 1 through 5 above).	√	√	√	*	√	√
7. Identify probable (based on historical experience) treatment sites that may contain habitat for special status species every year prior to work to determine the potential presence of special status flora and fauna using the CNDDB, relevant Habitat Conservation Plans (HCPs), NOAA Fisheries and USFWS websites, Calfish.org, and other biological information developed for other permits. Establish a buffer of reasonable distance, when feasible, from known special status species locations and do not allow application of pesticides/herbicides within this buffer without further agency consultations. Nonchemical methods are acceptable within the buffer zone when designed to avoid damage to any identified and documented rare flora and fauna.	√	√	√	*	√	
8. Vehicles driving on levees to travel through tidal marsh or to access sloughs or channels for surveillance or treatment activities will travel at speeds no greater than 10 miles per hour to minimize noise and dust disturbance.	√	√	√		√	√
9. District staff will implement site access selection guidelines to minimize equipment use in sensitive habitats including active nesting areas and to use the proper vehicles for onroad and offroad conditions.	√	√	√	√	√	√
10. Properly train all staff, contractors, and volunteer help to prevent spreading weeds and pests to other sites. The District headquarters contains wash rack facilities (including high-pressure washers) to regularly (in many cases daily) and thoroughly clean equipment to prevent the spread of weeds.	√	√	√	√	√	√
11. Operation of noise-generating equipment (e.g., chainsaws, wood chippers, brush-cutters, pickup trucks) will abide by the time-of-day restrictions established by the applicable local jurisdiction (i.e., City and/or County) if such noise activities would be audible to receptors (e.g., residential land uses, schools, hospitals, places of worship) located in the applicable local jurisdiction. Shut down all motorized equipment when not in use.	√	√	√	√	√	√

Best Management Practice (BMP)	Surveillance	Physical Control	Veg Mgmt	Bio Control	Chemical Control	Other
12. For operations that generate noise expected to be of concern to the public, the following measures will be implemented: – Measure 1: Provide Advance Notices: A variety of measures are implemented depending on the magnitude/nature of the activities undertaken by the District, and may include but are not limited to press releases, social media, District websites, e-mails, phone messages, hand delivered flyers, and posted signs. Public agencies and elected officials also may be notified of the nature and duration of the activities, including the Board of Supervisors or City Council, environmental health and agricultural agencies, emergency service providers, and airports. – Measure 2: Provide Mechanism to Address Complaints: District staff is available during regular business hours to respond to service calls and address concerns about nighttime operations.	√	√	√	√	√	√
13. The District will perform public education and outreach activities.	√	√	√	√	√	√
14. Engine idling times will be minimized either by shutting equipment and vehicles off when not in use or reducing the maximum idling time to 5 minutes. Correct tire inflation will be maintained in accordance with manufacturer's specifications on wheeled equipment and vehicles to prevent excessive rolling resistance. All equipment and vehicles will be maintained and properly tuned in accordance with manufacturer's specifications. All equipment will be checked by a certified visible emissions evaluator if visible emissions are apparent to onsite staff.	√	√	√	√	√	√
B. Tidal Marsh-Specific BMPs						
1. District staff will continue to implement the measures in the USFWS's "Walking in the Marsh: Methods to Increase Safety and Reduce Impacts to Wildlife/Plants". District staff will receive annual training and review of this document to remain up to date and current on this document and its methodologies for protecting sensitive species and the marsh habitat.	√	√	√	*	√	
2. District will minimize the use of equipment (e.g., ARGOs) in tidal marshes and wetlands. When feasible and appropriate, surveillance and control work will be performed on-foot with handheld equipment. Aerial treatment (helicopter and fixed wing) treatments will be utilized when feasible and appropriate to minimize the disturbance of the marsh during pesticide applications. When ATVs (e.g., ARGOs) are utilized techniques will be employed that limit impacts to the marsh including: slow speeds; slow, several point turns; using existing levees or upland to travel through sites when possible; use existing pathways or limit the number of travel pathways used.	√	√	√	*	√	√

Best Management Practice (BMP)	Surveillance	Physical Control	Veg Mgmt	Bio Control	Chemical Control	Other
3. District will minimize travel along tidal channels and sloughs in order to reduce impacts to vegetation used as habitat (e.g., Ridgway's rail nesting and escape habitat).	√	√	√		√	
4. District staff will minimize the potential for the introduction and spread of spartina, perennial pepperweed and other invasive plant species by cleaning all equipment, vehicles, personal gear, clothing, and boots of soil, seeds, and plant material prior to entering the marsh, and avoiding walking and driving through patches of perennial pepperweed to the maximum extent feasible.	√	√	√	*	√	√
5. When feasible, boats will be used to access marsh areas for surveillance and treatment of vectors to further reduce the risk of potential impacts that may occur when using ATVs to conduct vector management activities.	√	√	√	*	√	
6. The District currently references and provides staff training relevant to the USFWS "Walking in the Marsh: Methods to Increase Safety and Reduce Impacts to Wildlife/Plants" guidelines (USFWS undated). – District staff is trained to walk carefully in the marsh and to continuously look ahead of themselves to avoid potential wildlife disturbance (e.g., carefully make observations in their surroundings to detect flushing birds and nests). Specific care is taken when walking and performing surveillance in the vicinity of natural and manmade ditches or sloughs or in vicinity of cord grass habitat (e.g., rack line). – When walking in marshes District staff utilizes existing trails when possible (i.e., deer trails and other preexisting trails).	√	√	√	√	√	√
C. Salt Marsh Harvest Mouse (SMHM)						
1. Activities (surveillance, treatment, source reduction) within or adjacent to harvest mouse habitat will not occur within two hours before or after extreme high tides of 6.5 feet National Geodetic Vertical Datum (NGVD) or above as measured at the Golden Gate Bridge (corrected for time and tide height for the site) or when the marsh plain is completely inundated because suitable upland refugia cover is limited and potentially disturbance-creating activities could prevent mice from reaching available cover.	√	√	√	*	√	√
2. Vegetation removal is limited to the minimum amount necessary to allow for surveillance, treatment, and vector habitat reduction (vegetation management) to minimize or avoid loss of SMHM. Similarly, excavation, fill, or construction activities will also be limited to the minimum amount necessary to minimize/avoid loss of SMHM.	√	√	√		√	

Best Management Practice (BMP)	Surveillance	Physical Control	Veg Mgmt	Bio Control	Chemical Control	Other
3. Vegetation clearing will be conducted systematically within the project area to ensure that SMHM are encouraged to move toward remaining vegetation and are not trapped in islands of vegetation subject to removal and far from suitable cover.		√	√			
4. Each day, 30 minutes before commencement of vector habitat management (physical control, vegetation management) observations will be conducted for the presence of SMHM in the work area by staff trained by USFWS personnel in the safe and effective methods for observing SMHM.		√	√	*	√	
5. To the extent feasible, physical control, vegetation management and other vector habitat reduction activities will be conducted between December 1 and February 28 (outside of the SMHM breeding season). Surveillance, chemical control, biological control, and public education activities occur year-round and are therefore carefully coordinated with resource agencies to minimize potential impacts to SMHMs and their habitats.		√	√		√	
6. When walking in the marsh, existing trails will be used whenever possible. Specific care will be taken when walking and performing surveillance in the vicinity of natural and manmade ditches or sloughs or in the vicinity of tidal marsh habitat to avoid potential disturbance of SMHM.	√	√	√	*	√	√
7. District staff will receive training on measures to avoid impacts to SMHM.	√	√	√	*	√	√
8. If SMHM nests or adults are encountered during vector management activities, avoidance measures will be immediately implemented and findings will be reported to the appropriate resource agency.	√	√	√	*	√	√
D. Ridgway's Rail (RIRA)						
1. Activities (surveillance, treatment, source reduction) within or adjacent to RIRA's habitat will not occur within two hours before or after extreme high tides of 6.5 feet National Geodetic Vertical Datum (NGVD) or above as measured at the Golden Gate Bridge (corrected for time and tide height for the site) or when the marsh plain is completely inundated because suitable upland refugia cover is limited and potentially disturbance-creating activities could prevent RIRAs from reaching available cover.	√	√	√	*	√	√
2. Vegetation removal is limited to the minimum amount necessary to allow for surveillance, treatment, and vector habitat reduction (vegetation management) to minimize or avoid loss of RIRA. Similarly, excavation, fill, or construction activities will also be limited to the minimum amount necessary to minimize/avoid loss of RIRA.	√	√	√		√	

Best Management Practice (BMP)	Surveillance	Physical Control	Veg Mgmt	Bio Control	Chemical Control	Other
3. To the extent feasible, physical control, vegetation management and other vector habitat reduction activities will be conducted between September 1 and January 31 (outside of the RIRA breeding season). Surveillance, chemical control, biological control, and public education activities occur year-round and are therefore carefully coordinated with resource agencies to minimize potential impacts to RIRAs and their habitats.		√	√		√	
4. District staff will notify the appropriate resource agency prior to entering potential RIRA habitats and will regularly coordinate with the resource agency(ies) on the locations of breeding RIRAs and avoid breeding RIRAs to the extent feasible. Any observations of adverse effects to RIRAs will be reported by District staff.	√	√	√	√	√	
5. When walking in the marsh District staff will use existing trails whenever possible. Specific care will be taken when walking and performing surveillance in the vicinity of natural and manmade ditches or sloughs or in the vicinity of tidal marsh habitat to avoid potential disturbance of RIRAs.	√	√	√	*	√	√
6. Entry into suitable breeding habitat for RIRAs will be minimized. When entry is required, the preferred method will be by foot. Other entry methods will be based on consultation with the appropriate resource agency.	√	√	√	*	√	√
7. District staff will receive training on measures to avoid impacts to RIRAs.	√	√	√	*	√	√
8. If RIRA nests or adults are encountered during vector management activities, avoidance measures, as provided during training from the resource agencies, will be immediately implemented and findings will be reported to the appropriate resource agency.	√	√	√	*	√	√
E. Soft Bird's Beak (SBB)						
1. District staff will receive training on the identification, biology and preferred habitat of soft bird's beak.	√	√	√	*	√	√
2. When possible, project actions to be conducted in areas containing suitable habitat for this species will occur during the time period when soft bird's beak is in bloom and identifiable (July-November), so that any soft bird's beaks plants observed can be avoided and documented.	√	√	√	*	√	√
3. District staff will coordinate with Napa-Sonoma Marshes Wildlife Area (CDFW) and San Pablo Bay National Wildlife Refuge regarding the locations of known soft bird's beak populations, so that these populations can be avoided. Flagging will be used to identify the boundaries of known soft bird's beak populations.	√	√	√	*	√	√

Best Management Practice (BMP)	Surveillance	Physical Control	Veg Mgmt	Bio Control	Chemical Control	Other
4. When possible, vector management activities will be conducted on foot using hand equipment.	√	√	√	*	√	√
F. Vegetation Management						
1. Consultations will be made with the appropriate resource agency to discuss proposed vegetation management work, determine potential presence of sensitive species and areas of concern, and any required permits.		√	√			
2. Vegetation management work performed will typically be by hand, using handheld tools, to provide access to vector habitat for surveillance, and when needed control activities. Tools used include: machetes, small garden variety chain saw, hedge trimmers and "weed-eaters".		√	√			
3. District will consult and coordinate with resource agencies as well as have all necessary permits prior to the commencement of work using heavy equipment (e.g., larger than handheld/garden variety tools such as small excavators with rotary mowers) in riparian areas.		√	√			
4. Minor trimming of vegetation (e.g., willow branches approximately three inches in diameter or less, blackberry bushes, and poison oak) to the minimum extent necessary will occur to maintain existing paths or create access points through dense riparian vegetation into vector habitat. This may include minor trimming of overhanging limbs, brush and blackberry thickets that obstruct the ability to walk within creek channels. Paths to be maintained will not be a cut, defined corridor but rather a path maintained by selective trimming of overhanging or intrusive vegetation. Paths to be maintained will range in width from 3 to 6 feet across.		√	√			
5. Downed trees and large limbs that have fallen due to storm events or disease will be cut only to the extent necessary to maintain existing access points or to allow access to vector habitats.		√	√			
6. Vegetation management work will be confined to October 1 to April 30[5] to minimize potential impacts to sensitive species, especially breeding birds. When work is expected to occur between February 1 and April 30, additional consultations will occur with appropriate resource agencies to help identify locations of active nests of raptors or migratory birds as well as any additional protection measures that will need to be implemented prior to commencement of work.		√	√			

[5] Dates are from MSMVCD's Final LSAA permit with CDFW; Notification No. 1600-2010-2053-R3, Public Health/Mosquito Control Access Maintenance (October 6, 2010.

Best Management Practice (BMP)	Surveillance	Physical Control	Veg Mgmt	Bio Control	Chemical Control	Other
7. Every effort will be made to complete vegetation management in riparian corridors prior to the onset of heavy rains. Maintenance work to be done in early spring will be limited to trimming new shoot growth, poison oak, blackberries, and downed trees that block these paths.		√	√			
8. District staff will work with care and caution to minimize potential disturbance to wildlife, while performing vegetation management activities within or near riparian corridors.		√	√			
9. Within suitable habitat for California Freshwater Shrimp (*Syncaris pacifica*), no in-channel vegetation will be removed, trimmed, or otherwise disturbed. District staff will work with resource agencies to determine locations of suitable habitat for California Freshwater Shrimp and receive written authorization to proceed prior to commencement of vegetation management activities.		√	√			
10. If suitable habitat necessary for special status species is found, including vernal pools, and if nonchemical physical and vegetation management control methods have the potential for affecting special- status species, then the District will coordinate with the CDFW, USFWS, and/or NMFS before conducting control activities within this boundary or cancel activities in this area. If the District determines no suitable habitat is present, control activities may occur without further agency consultations.		√	√			
11. When using heavy equipment for vegetation management, District staff (and contractors) will minimize the area that is affected by the activity and employ all appropriate measures to minimize and contain turbidity. Heavy equipment will not be operated in the water and appropriate containment and cleanup systems will be in place on site to avoid, contain, and clean up any leakage of toxic chemicals.		√	√			
G. Maintenance / Construction and Repair of Tide Gates and Water Structures in Waters of the U.S.						
1. District staff will consult with appropriate resource agencies (USACE, USFWS, CDFW, NMFS, BCDC, RWQCB) and obtain all required permits prior to the commencement of ditch maintenance or construction within tidal marshes.		√				

Best Management Practice (BMP)	Surveillance	Physical Control	Veg Mgmt	Bio Control	Chemical Control	Other
2. Work plans for the upcoming season' proposed work as well as a summary of the last season' completed work will be submitted for review and comment to USACE, USFWS, NMFS, CDFW, BCDC and RWQCB no later than July 1 of each year for which work is being proposed. The work plan will include a delineation of all proposed ditching overlain on topographic maps at a minimum of 1" = 1000' scale, with accompanying vicinity maps. The plan will also indicate the dominant vegetation of the site, based on subjective estimates, the length and width of the ditches to be maintained, cleared or filled, and the estimated date the work will be carried out.		√				
3. All maintenance work will be done at times that minimize adverse impacts to nesting birds, anadromous fish, and other species of concern, in consultation with USFWS, NMFS, and CDFW. Work conducted will, whenever possible, be conducted during approved in water work periods for that habitat, considering the species likely to be present. For example, tidal marsh work will be conducted between September 1 and January 31, where possible and not contraindicated by the presence of other sensitive species. Similarly, in water work in waterbodies that support anadromous fish, work will be conducted between July 1 and September 30[6].		√	√			
4. Care will be taken to minimize the risk of potential disruption to the indigenous aquatic life of a waterbody in which ditch maintenance is to take place, including those aquatic organisms that migrate through the area.		√				
5. Staging of equipment will occur on upland sites.		√				
6. Mats or other measures will be taken to minimize soil disturbance (e.g., use of low ground pressure equipment) when heavy equipment is used.		√				
7. All projects will be evaluated prior to bringing mechanical equipment on site, in order to identify and flag sensitive sites, select the best access route to the work site consistent with protection of sensitive areas, and clearly demarcate work areas.		√				
8. Measures will be taken to minimize impacts from mechanical equipment, such as hand ditching as much as possible; reducing turns by track-type vehicles, taking a minimum number of passes with equipment, varying points of entry, driving vehicles at low speed, and not driving on open mud and other soft areas.		√				

[6] Dates are from District's USACE source reduction permit. July 31, 2007.

Best Management Practice (BMP)	Surveillance	Physical Control	Veg Mgmt	Bio Control	Chemical Control	Other
9. Discharges of dredged or fill material into tidal waters will be minimized or avoided to the maximum extent possible at the project site and will be consistent with all permit requirements for such activity. No discharge of unsuitable material (e.g., trash) will be made into waters of the United States, and material that is discharged will be free of toxic pollutants in toxic amounts (see section 307 of the Clean Water Act). Measures will be taken to avoid disruption of the natural drainage patterns in wetland areas.		√				
10. Discovery of historic or archeological remains will be reported to USACE and all work stopped until authorized to proceed by the appropriate regulatory authorities/resource agencies.		√				
11. Ditching that drains high marsh ponds will be minimized to the extent possible in order to protect the habitat of native salt pan species.		√				
12. No spoils sidecast adjacent to circulation ditches will exceed 8 inches above the marsh plain to minimize risk of colonization of spoils by invasive, nonnative plants and/or the spoils lines from becoming access corridors for unwanted predators (e.g., dogs, cats, red fox). Sidecast spoil lines exceeding 4 inches in height above the marsh plain will extend no more than 6 feet from the nearest ditch margin. Any spoils in excess of these dimensions will be hydraulically redispersed on site (e.g., by rotary ditcher), or removed to designated upland sites (per conditions of resource agency issued permits). Sidecast spoil lines will be breached at appropriate intervals to prevent local impediments to water circulation.		√				
13. If review of the proposed work plan by USACE, USFWS, or CDFW determines the proposed maintenance is likely to destroy or damage substantial amounts of shrubby or sub-shrubby vegetation (e.g., coyote brush, gumplant) on old sidecast spoils, the District will provide a quantitative estimate of the extent and quality of the vegetation, and provide a revegetation plan for the impacted species prepared by a biologist/botanist with expertise in marsh vegetation. The Corps approved revegetation plan will be implemented prior to April 1 of the year following the impacts.		√				
14. Small ditch maintenance work will be performed by hand, whenever possible, using handheld shovels, pitch forks, etc., and small trimmers such as "weed-eaters". (Note: the majority of small ditch work performed by the District is by hand.)		√				
15. Work will be done at low tide (for tidal areas) and times of entry will be planned to minimize disruption to wildlife.		√				

Best Management Practice (BMP)	Surveillance	Physical Control	Veg Mgmt	Bio Control	Chemical Control	Other
16. In marshes which contain populations of invasive nonnative vegetation such as pepperweed or introduced spartina, sidecast spoils will be surveyed for the frequency of establishment of these species during the first growing season following deposition of the spoils. The results of the surveys will be reported to the USACE, USFWS and CDFW. If it is determined the sidecasting of spoils resulted in a substantial increase in the distribution or abundance of the nonnative vegetation which is detrimental to the marsh, the District will implement appropriate abatement measures after consultation with the USACE, USFWS and CDFW.		√				
17. When possible (i.e., with existing labor and vehicles), refuse such as tires, plastic, and man-made containers found at the work site will be removed and properly discarded.		√	√			
H. Applications of Pesticides, Surfactants, and/or Herbicides						
1. District staff will conduct applications with strict adherence to product label directions that include approved application rates and methods, storage, transportation, mixing, and container disposal.			√	*	√	
2. District will avoid use of surfactants when possible in sites with aquatic nontargets or natural enemies of mosquitoes present such as nymphal damselflies and dragonflies, dytiscids, hydrophilids, corixids, notonectids, ephydrids, etc. Surfactants are the only tool that can be used with pupae to prevent adult mosquito emergence. The District will use a microbial larvicide (Bti, Bs) or IGR (e.g., methoprene) instead or another alternative when possible.			√		√	
3. Materials will be applied at the lowest effective concentration for a specific set of vectors and environmental conditions. Application rates will never exceed the maximum label application rate.			√	*	√	
4. To minimize application of pesticides, application of pesticides will be informed by surveillance and monitoring of vector populations.			√		√	
5. District staff will follow label requirements for storage, loading, and mixing of pesticides and herbicides. Handle all mixing and transferring of pesticides and herbicides within a contained area.			√		√	
6. Postpone or cease application when predetermined weather parameters exceed product label specifications, when wind speeds exceed the velocity as stated on the product label, or when a high chance of rain is predicted and rain is determining factor on the label of the material to be applied.			√	*	√	

Best Management Practice (BMP)	Surveillance	Physical Control	Veg Mgmt	Bio Control	Chemical Control	Other
7. Applicators will remain aware of wind conditions prior to and during application events to minimize any possible unwanted drift to waterbodies, and other areas adjacent to the application areas.			√	*	√	
8. Spray nozzles will be adjusted to produce larger droplet size rather than smaller droplet size. Use low nozzle pressures where possible (e.g., 30 to 70 pounds per square inch). Keep spray nozzles within a predetermined maximum distance of target weeds (e.g., within 24 inches of vegetation for hand application) or vectors. Adjusting droplet size would only apply to larvicides, herbicides and non-ULV applications. Use ULV applications that are calibrated to be effective and environmentally compatible at the proper droplet size (about 10-30 microns).			√	*	√	
9. Clean containers at an approved site and dispose of at a legal dumpsite or recycle in accordance with manufacturer's instructions if available.			√	*	√	
10. Special status Aquatic Wildlife Species: – A CNDDB search was conducted in 2012 and the results incorporated into Appendix A for this PEIR. An update was completed in November 2014 and the results incorporated into Section 4.1.2 of this PEIR. District staff communicates with state, federal, and county agencies regarding sites that have potential to support special status species. Many sites where the District performs surveillance and control work have been visited by staff for many years and staff is highly knowledgeable about the sites and habitat present. If new sites or site features are discovered that have potential to be habitat for special status species, the appropriate agency and/or landowner is contacted and communication initiated. – Use only pesticides, herbicides, and adjuvants approved for aquatic areas or manual treatments within a predetermined distance from aquatic features (e.g., within 15 feet of aquatic features). Aquatic features are defined as any natural or man-made lake, pond, river, creek, drainage way, ditch, spring, saturated soils, or similar feature that holds water at the time of treatment or typically becomes inundated during winter rains. – If suitable habitat for special status species is found, including vernal pools, and if aquatic-approved pesticide, herbicide, and adjuvant treatment methods have the potential for affecting the potential species, then the District will coordinate with the CDFW, USFWS, and/or National Marine Fisheries Service (NMFS) before conducting treatment activities within this boundary or cancel activities in this area. If the District determines no suitable habitat is present, treatment activities may occur without further agency consultation.			√	*	√	

Best Management Practice (BMP)	Surveillance	Physical Control	Veg Mgmt	Bio Control	Chemical Control	Other
11. District staff will monitor sites post-treatment to determine if the target vector or weeds were effectively controlled with minimum effect to the environment and nontarget organisms. This information will be used to help design future treatment methods in the same season or future years to respond to changes in site conditions.			√	*	√	
12. Do not apply pesticides that could affect insect pollinators in liquid or spray/fog forms over large areas (more than 0.25 acres) during the day when honeybees are present and active or when other pollinators are active. Preferred applications of these specific pesticides are to occur in areas with little or no honeybee or pollinator activity or after dark. These treatments may be applied over smaller areas (with hand held equipment), but the technician will first inspect the area for the presence of bees and other pollinators. If pollinators are present in substantial numbers, the treatment will be made at an alternative time when these pollinators are inactive or absent.			√		√	
13. The District will provide notification to the public (24 – 48 hours in advance if possible) and/or appropriate agency(ies) when applying pesticides or herbicides for large-scale treatments (e.g., fixed-wing aircraft or helicopters) that will occur in close proximity to homes, heavily populated, high traffic, and sensitive areas. The District infrequently applies or participates in the application of herbicides in areas other than District facilities.			√	*	√	
I. Hazardous Materials and Spill Management						
1. Exercise adequate caution to prevent spillage of pesticides during storage, transportation, mixing or application of pesticides. Report all pesticide spills and cleanups (excepting cases where dry materials may be returned to the container or application equipment).			√	*	√	
2. Maintain a pesticide spill cleanup kit and proper protective equipment at the District's Service Yard and in each District truck used for pesticide transport.			√	*	√	
3. Manage the spill site to prevent entry by unauthorized personnel. Contain and control the spill by stopping it from leaking or spreading to surrounding areas, cover dry spills with polyethylene or plastic tarpaulin, and absorb liquid spills with appropriate absorbent materials.			√	*	√	
4. Properly secure the spilled material, label the bags with service container labels identifying the pesticide, and deliver them to a District/Field Supervisor for disposal.			√	*	√	

Best Management Practice (BMP)	Surveillance	Physical Control	Veg Mgmt	Bio Control	Chemical Control	Other
5. A hazardous spill plan will be developed, maintained, made available, and staff trained on implementation and notification for petroleum-based or other chemical-based materials prior to commencement of vector treatment activities.	√	√	√	√	√	√
6. Field-based mixing and loading operations will occur in such a manner as to minimize the risk of accidental spill or release of pesticides.			√		√	
J. Worker Illness and Injury Prevention and Emergency Response						
1. Equip all vehicles used in wildland areas with a shovel and/or a fire extinguisher during the fire season.	√	√	√	√	√	√
2. Train employees on the safe use of equipment and machinery, including vehicle operation.	√	√	√	√	√	√
3. District will regularly review and update their existing health and safety plan to maintain compliance with all applicable standards. Employees will be required to review these materials annually.	√	√	√	√	√	√

3 Urban and Rural Land Uses

Chapter 3 evaluates potential impacts to urban and rural land uses from Program implementation. The focus of this chapter is on the consistency of the Program with local and regional land use plans and policies in effect in the Program Area. Because the exact location and timing of potential vector control activities are unknown, this analysis has been conducted at a programmatic level.

Section 4.1, Environmental Setting, presents an overview of the types of land uses found in the Program Area, including a description of public lands in the Program Area where vector control measures could be implemented. It also presents federal, state, and local ordinances and regulations that are related to pesticide use in the Program Area. Section 4.2, Environmental Impacts and Mitigation Measures, presents the following:

> Environmental concerns and evaluation criteria

> Evaluation methods and assumptions

> Discussion of the land use impacts from the No Program and Program alternatives, and recommendations for mitigation, if required, for those impacts

> Cumulative impacts related to land use

> Summary of environmental impacts due to land use conflicts

3.1 Environmental Setting

3.1.1 Overview of Urban and Rural Land Use

Generally, implementation of vector control activities could occur on a wide range of land uses within the Program Area covered under the Proposed Program, which covers Marin and Sonoma counties. In addition, actions can also be taken in adjacent counties as needed, including Lake, Mendocino, Napa, and Solano counties. This six-county region representing the Program Area is characterized by both urban and rural settings. Urban areas include residential, commercial, and industrial uses that tend to be located in incorporated areas. Other parts of the Program Area are rural in character, including agricultural land, rural residential, open space, and other public lands that are generally undeveloped.

Control measures specific to mosquitoes are focused on aquatic habitats, including man-made and natural areas, such as marshes, lakes and ponds, rivers and streams, seasonal wetlands, and irrigated pastures. These types of habitats typically are found in rural areas. Mosquito control measures can also occur at developed facilities found in urban areas or other areas that retain water, such as stormwater detention basins, flood control channels, spreading grounds, street drains and gutters, wash drains, animal troughs, artificial containers, tire piles, fountains, ornamental fishponds, and swimming pools.

3.1.2 Public Lands

Although vector control measures can be implemented on lands irrespective of landownership, large expanses of aquatic and terrestrial habitat are commonly found on public lands, such as National Wildlife Refuges administered at the federal level by the USFWS. Table 3-1 presents the extent of federal land in the Program Area based on US Department of the Interior information for lands eligible for “payments in lieu of taxes” to county governments. Many lands within the National Wildlife Refuge (NWR) system administered by USFWS are not eligible for payments in lieu of taxes and are not included in the table, which is focused on lands eligible for “payments in lieu of taxes.” Federal lands (e.g., Bureau of Land Management and NWRs) do not pay property taxes to the state, counties, or local governments. To

address this issue, the federal government has established a program called Payment In Lieu of Taxes (PILT) that makes nominal payments to the state and counties to help defray part of the tax revenues lost due to the establishment of designated federal lands (e.g., some NWRs). Local (noncounty) governments are not eligible to receive the funds, as they are not a state or county taxing entity that has lost tax base due to federal action.

The Program Area also has extensive areas of public land managed by state agencies, namely California State Parks, as well as community and regional parks managed by local parks and recreation departments of affected municipalities and special districts.

Table 3-1 Federal Lands in the Program Area, FY-2012 (acres)

	Agency						
County	**BLM**	**USFS**	**USBR**	**NPS**	**USACE**	**USFWS***	**Total**
Lake	126,656	256,613	80	0	0	0	383,349
Marin	0	0	0	78,713	0	0	78,713
Mendocino	121,313	178,884	0	0	3,109	0	303,306
Napa	31,737	0	28,585	0	5	0	60,327
Solano	2,157	0	881	0	2,720	0	5,758
Sonoma	7,158	0	0	0	14,317	0	21,475
Total	**289,021**	**435,497**	**29,546**	**78,713**	**20,151**	**0**	**852,928**

Source: US Department of Interior (2013)

Notes:

*Many lands within the National Wildlife Refuge system administered by USFWS are not eligible for payments in lieu of taxes and are not included in the table.

BLM = Bureau of Land Management
NPS = National Park Service
USACE = US Army Corps of Engineers
USBR = US Bureau of Reclamation
USFS = USDA Forest Service
USFWS = US Fish and Wildlife Service

The USFWS manages San Pablo Bay NWR. San Pablo Bay NWR was established to protect important stopover and wintering grounds for waterfowl, shorebirds, and other migratory birds. It is also designed to support recovery of endangered species, in particular, the salt marsh harvest mouse and California clapper rail. The NWR comprises 23,700 acres of land and water in Marin, Sonoma, Napa, and Solano counties. The District provides mosquito surveillance and control on approximately 5,067 acres of the NWR's tidal marsh habitat.

Marin County is comprised of 11 cities and towns and unincorporated area covering 606 square miles of land and water. County goals include "*A Healthy and Safe Lifestyle. Marin residents will have access to a proper diet, health care, and opportunities to exercise, and the community will maintain very low tobacco, alcohol, drug abuse, and crime rate*" (Marin County 2007, p. 1.3-12). An estimated 47 percent of the county has been developed with urban, suburban residential, and agricultural uses (Marin County 2007, p. 2.4-9). Marin County Open Space District (MCOSD) is the local agency responsible for creating the County's own system of public open space. The district's mission is "*to enhance quality of life in Marin through the acquisition, protection and responsible stewardship of ridgelands, baylands, and environmentally sensitive lands targeted for preservation in the Countywide Plan*" (Marin County 2007, p. 2.8-2). The Open Space District (2014) currently manages 34 open-space preserves comprising approximately 16,000 acres. Other

public agencies and nongovernmental organizations, most notably Golden Gate National Recreation Area, Point Reyes National Seashore, California State Parks, Marin Municipal Water District, North Marin Water District, and Marin Agricultural Land Trust, also protect open-space land in Marin, but according to their own missions and for their own purposes. All (with the exception of Marin Agricultural Land Trust) share a responsibility for managing extensive lands, amounting to thousands of acres each, that are more or less in a natural condition and open to the public (Marin County 2007, p. 2.8-2).

Sonoma County has a total area of 1,768 square miles, of which 1,576 square miles is land and 192 square miles (10.9 percent) is water according to the US Census Bureau (cited in Wikipedia 2014), The boundary with Marin County runs from the mouth of Estero Americano at Bodega Bay, up Americano Creek, then overland to San Antonio Creek, and down the Petaluma River to its mouth at the northwestern corner of San Pablo Bay, which adjoins San Francisco Bay. The southern edge of Sonoma County comprises the northern shore of San Pablo Bay between the Marin County border at the Petaluma River and the border with Solano County at Sonoma Creek. The Petaluma River, which flows into San Pablo Bay, is navigable up to the city of Petaluma. The Petaluma River, Tolay Creek, and Sonoma Creek enter the bay at the county's southernmost tip. The intertidal zone where they join the bay is Napa Sonoma Marsh. This marsh has an area of 48,000 acres, of which 13,000 acres are abandoned salt evaporation ponds. The United States Government has designated 13,000 acres in Napa Sonoma Marsh as San Pablo Bay National Wildlife Refuge (Wikipedia 2014). Sonoma County contains 52 regional parks with 777 developed acres, 57,203 undeveloped acres, 175 miles of trails, and annual park users/park visits of 5,603,743 (Sonoma County 2014).

3.1.3 Regulatory Setting

3.1.3.1 Federal

No federal regulations and/or policies govern land use in the Program Area, except for management plans related to federal land holdings. However, the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)[1] regulates, at the federal level, pesticide distribution, sale, and use. For more information on FIFRA, refer to Section 7.1.4.1.1 (Human Health).

3.1.3.2 State

Similar to the federal level, the State of California has no direct authority on local land use on private lands with the exception of requirements related to general plan development and zoning consistency. Specifically, California Government Code Section 65300 et seq. establishes the obligation of cities and counties to adopt and implement general plans. A general plan is a comprehensive, long-term strategy document that sets forth the expected location and general type of physical development expected in the city or county developing the document. In addition, State Zoning Law (California Government Code Section 65800 et seq.) establishes that zoning ordinances, which are laws that define allowable land uses in a specific district, are required to be consistent with the general plan and any applicable specific plans. Land use on state-managed public lands is regulated pursuant to any applicable land use plans and policies administered by each state agency.

From a land use perspective, the key regulatory consideration at the state level is related to the concept of preemption. Preemption refers to laws at one level of government taking precedence over laws of a lower level. As such, no entity at the lower level can pass a law inconsistent with the law at the higher level. The California Constitution also allows the state to preempt local jurisdictions. California Food and Agricultural Code Section 11501.1 states that no ordinance or regulation of local government "*may prohibit or in any way attempt to regulate any matter relating to the registration, sale, transportation, or use of pesticides, and any of these ordinances, laws or regulations are void and of no force or effect*".

[1] 7 United States Code (USC) Section 136 et seq. (1996)

3.1.3.3 Local

Each of the municipalities (i.e., counties and incorporated cities) in the Program Area maintains its own general plan and/or zoning ordinance that regulates allowable land use and related activities for designated areas within its jurisdiction. For example, the Land Use Element of the Marin Countywide Plan provides the distribution, location, and extent of uses of land for housing, business, industry, open space, agriculture, natural resources, recreation, and enjoyment of scenic beauty, education, public buildings and grounds, solid and liquid waste disposal facilities, and other uses (Marin County 2008). For each appropriate land-use category, it includes standards for population density and building intensity.

Typically, policies and programs related directly to pesticide use are outside the purview of local planning and zoning regulation. However, some cities and counties have enacted regulations on pesticide use as part of their municipal code. Local governing bodies may pass ordinances that regulate or restrict pesticide use in their own operations. However, these restrictions do not apply to state operations and would not be applicable to treatments the District proposes under the Program because California state law preempts local regulation and restriction of pesticide use. The District is a regulatory agency formed pursuant to California Health and Safety Code Section 2000 et seq. State law charges the District with the authority and responsibility to take all necessary or proper steps for the control of mosquitoes and other vectors in the District (see Section 1.1.3).

Several municipalities within the Program Area have adopted specific regulations regarding the use of pesticides and/or have developed IPM plans or programs. In the Program Area, these municipalities include, but are not limited to (Californians for Pesticide Reform 2013):

> City of Belvedere. Repealed the City's previous herbicide and pesticide use policy that eliminated pesticide and herbicide/landscape maintenance products that adversely affect the health of humans and the environment on June 9, 2014, when a new Integrated Pest Management (IPM) Policy was adopted. The new IPM Policy serves as the basis of the required Pesticide-Related Toxicity Program. An exception to this new pesticide policy was made in order to ". . . *control the proliferation of biting or stinging insects such as yellow jackets, wasps, mosquitoes, and other similar pests. As control of those pests on City property is normally performed by the Marin-Sonoma Mosquito and Vector Control District, the City authorizes pesticide use, but will advocate for the use of the least toxic product on a case-by-case basis. In addition, the City will exempt any governmental entity from the provisions of this Resolution whose authority pre-empts that of the City.*" (City of Belvedere 2014)

> Town of Fairfax. Prohibited the use of pesticides (including herbicides) on public land. Effective April 6, 2001, Ordinance #687 prohibits the use of pesticides (including herbicides) on Fairfax parks, open space parcels and public rights of way and buildings owned and maintained by the Town of Fairfax. "*Use*" shall be defined as both aerial and ground spraying and or dusting and all other ground applications. The only exceptions to the use of pesticides under Section 8.40.30 are the same as those found in Section 8.40.44; and, in addition an exception may be approved by a two-thirds super majority vote of the full Town Council with a mandatory finding that the health, safety and welfare of the community is so threatened that an emergency exists, that no reasonable alternative is available, and the prohibition of the use of pesticides would create the potential for allowing a significant adverse impact on the town. (Town of Fairfax 2001)

> County of Marin. Enacted Integrated Pest Management (IPM) Ordinance No. 3521 that created an IPM plan for the county of Marin that governs and guides the control of pests on property the County of Marin owns, manages, and leases. The IPM program uses best practices and science to protect the health of the public and environment, manage their properties, minimize loss due to pests, and reduce pesticide use (see Draft PEIR Section 4.1.3.3.1). The Countywide General Plan contains the following open space implementation policy in the Natural Systems and Agriculture Element (Marin County 2007, p. 2.8-6):

"OS-1.c Utilize Integrated Pest Management. Minimize the use of pesticides and herbicides in open space management."

> Town of Corte Madera. Adopted Resolution No. 3257 approving an Integrated Pest Management Program dated Aug. 6, 2002, that contains procedures, rules, policies and suggested practices applicable to the use of pesticides. It is the policy of the Town to use least-toxic IPM principles to manage pest populations on Town property. Except for pesticides granted an emergency exemption, the Town will not use any products on the banned use product list. If it is determined that an EPA registered pesticide must be used, then the least-hazardous material will be chosen. Products will be divided into three classifications: Approved Use List, Limited Use List and Banned Use List. If the use of a material not on either the Approved Use List of the Limited Use List is deemed necessary, the IPM Coordinator may apply for an emergency exemption. The Approved List includes, but, is not limited to:

  - Insecticides, rodenticides bats and traps
  - Natural products on the FIFRA's 25 (b) list (40 CFR part 152.25 (g) (l)
  - Natural products on the California Certified Organic Farmers organic list
  - EPA GRAS-generally recognized as safe products pursuant to federal EPA
  - Biological controls, such as parasites and predators
  - Microbial pesticides
  - Insect growth regulators

  The IPM Coordinator will make a recommendation to the Town Council to allow a pesticide not on the Approved Use List or Limited Use List based upon a finding that the protection of public health requires the use of that pesticide due to an emergency. (Town of Corte Madera 2002)

> Town of San Anselmo. Committed to a least toxic IPM policy to reduce the dependence on chemical products for pest management. No pesticides may be used at Town sites, except in accordance with the Town's printed IPM Policy. The Policy contains provisions similar to Corte Madera's IPM Policy described above. (Town of San Anselmo undated)

3.2 Environmental Impacts and Mitigation Measures

The evaluation of land use impacts in the Program Area is presented below. Program impacts on urban and rural land uses were evaluated based on the significance criteria presented in Section 3.2.1.

3.2.1 Evaluation Concerns and Criteria

The following concerns associated with urban and rural land uses were raised during the public scoping process:

> Aspects of the Program that diminish recreational experience of park visitors of the regional parks and trails within the Program Area.

  - Effects on recreational land use are covered in this section.

> Impacts at school sites.

  - The Program would not alter land uses at public or private school sites and schools would continue to operate similarly to existing conditions. However, the District coordinates and often works collaboratively with individual schools and school districts regarding vector control. The District notifies schools prior to performing vector control activities on school grounds (i.e., larvicide and adulticide applications, trapping, and surveillance). These activities have been modified based on the response from the school involved.

> Local community regulations regarding pesticides.
  - Potential effects related to consistency with local community regulations are covered in this section.

Based on the CEQA Guidelines and professional judgment, Program impacts to urban and rural land uses would be considered potentially significant if the Program would:

> Physically divide an established community.
  - The Program does not propose any change in land use or new developments and, therefore, would have no impact related to physically dividing an established community; as a result, this criterion is not applicable to the Program.

> Result in adverse impacts on the quantity and/or quality of recreational land uses.

> Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the Program (including, but not limited to the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect.

> Conflict with any applicable habitat conservation plan or natural community conservation plan.
  - The Program's potential to conflict with any applicable habitat conservation plan or natural community conservation plan is discussed in Chapter 4, *Biological Resources – Aquatic*, and in Chapter 5, *Biological Resources – Terrestrial*.

The environmental impact topics of the potential to conflict with applicable plans, policies, or regulations within the Program treatment areas and potential effects on recreational land uses are evaluated for each Program alternative below. Vector management activities have the potential to affect the experience of recreationists on designated park lands and human activities occurring in rural areas (e.g., bicyclists along rural roads, hikers, and winery visitors). Program activities would occur in agricultural areas, including vineyards and wineries, but not inhibit normal operations in these areas.

3.2.2 Evaluation Methods and Assumptions

The methodology for evaluating land use impacts consists of (1) reviewing existing recreational opportunities in the Program Area and analyzing how proposed vector control measures would affect recreational land uses and (2) reviewing the Program alternatives in the context of state and local laws and regulations pertaining to pesticide use.

The District has implemented and will continue to implement the following BMPs (from Table 2-6) that are applicable to District activities in all areas within the Program Area including rural recreational, agricultural, and open-space areas:

> District staff has had long standing and continues to have cooperative, collaborative relationships with federal, state, and local agencies. The District regularly communicates with agencies regarding the District's operations and/or the necessity and opportunity for increased access for surveillance, source reduction, habitat enhancement, and the presence of special-status species and wildlife. The District often participates in and contributes to interagency projects. The District will continue to foster these relationships, communication, and collaboration. (BMP A1)

> District staff will work with care and caution to minimize potential disturbance to wildlife while performing surveillance and vector treatment/population management activities. (BMP A6)

> Vehicles driving on levees to travel through tidal marsh or to access sloughs or channels for surveillance or treatment activities will travel at speeds no greater than 10 miles per hour to minimize noise and dust disturbance. (BMP A8)

> Operation of noise-generating equipment (e.g., chainsaws, wood chippers, brush-cutters, pickup trucks) will abide by the time-of-day restrictions established by the applicable local jurisdiction (i.e., City and/or County) if such noise activities would be audible to receptors (e.g., residential land uses, schools, hospitals, places of worship) located in the applicable local jurisdiction. Shut down all motorized equipment when not in use. (BMP A11)

> For operations that generate noise expected to be of concern to the public, the following measures will be implemented: (BMP A12)

- Measure 1: Provide Advance Notices: A variety of measures are implemented depending on the magnitude/nature of the activities the District undertakes and may include, but are not limited to, press releases, social media, District websites, emails, phone messages, hand-delivered flyers, and posted signs. Public agencies and elected officials also may be notified of the nature and duration of the activities, including the Board of Supervisors or City Council, environmental health and agricultural agencies, emergency service providers, and airports.
- Measure 2: Provide Mechanism to Address Complaints: District staff is available during regular business hours to respond to service calls and address concerns about nighttime operations.

3.2.3 Surveillance Alternative

Impacts on Recreational Land Uses

The Surveillance Alternative involves utilization of various methods to monitor targeted vectors in terms of their location and distribution. District staff may implement surveillance techniques in recreational settings, but they would not likely interfere with existing recreational uses. Recreationists would continue to use recreation areas; and potential impacts on the quality of the recreational experience, such as from noise, would be minor.

> **Impact LU-1:** Surveillance of vectors would not appreciably impact the quantity and/or quality of recreational opportunities in the Program Area. This impact is **less than significant** and no mitigation is required.

Conflict with Applicable Land Use Regulations and Policies

This alternative does not involve the use of chemical pesticides to control vectors and, therefore, would not be inconsistent with local policies on IPM and local ordinances restricting pesticide use.

> **Impact LU-2:** Surveillance of vectors would not be inconsistent with applicable land use regulations. **No impact** would occur.

3.2.4 Physical Control Alternative

Impacts on Recreational Land Uses

The Physical Control Alternative entails changes to the extent or composition of vector habitats as a means of vector control or “source reduction”. Alterations of certain types of habitats for vector control may adversely affect the recreational quality of that habitat, particularly applicable to aquatic habitats that are used either directly or indirectly for recreational purposes, e.g., water bodies used by anglers or waterfowl that are targeted by hunters. The District undertakes a variety of physical control projects in freshwater bodies and saline habitats, including marshes and ponds, consistent with regulatory requirements (see Section 2.8) in a manner that generally maintains or improves habitat values for desirable species to control mosquitoes. The control of mosquitoes in aquatic habitats prevents them from annoying/biting recreationists, which enhances the recreational experience. In addition, physical control measures that would be implemented would target other types of vector habitats that generally do not support recreational uses. As a result, this alternative would continue with practices used under existing conditions, and would not be likely to interfere with existing recreational uses except on a limited basis

(i.e., ditch/channel maintenance using equipment and vehicles that could close a trail or introduce noise), and recreationists would continue to use recreation areas in a similar fashion to the present. Potential impacts on the quality of the recreational experience, including noise-related effects, would be minor.

> **Impact LU-3:** Physical control of vector habitat would not appreciably impact the quantity and/or quality of recreational opportunities in the Program Area. This impact is **less than significant** and no mitigation is required.

Conflict with Applicable Land Use Regulations and Policies

Physical control does not alter the type of land use (e.g., residential, commercial, industrial, resource conservation, and agricultural). This alternative does not interfere with existing land uses and does not involve the use of chemical pesticides to control vectors and, therefore, would not be inconsistent with local land use plans and local ordinances restricting pesticide use.

> **Impact LU-4:** Physical control of vectors would not be inconsistent with applicable land use regulations. **No impact** would occur.

3.2.5 Vegetation Management Alternative

Impacts on Recreational Land Uses

The Vegetation Management Alternative involves control or removal of vegetation in an effort to control or facilitate surveillance and control of vectors and could occur in parks and wildlife protection areas. The District coordinates with landowners/managers and, where applicable, resource agencies prior to commencing work, whether trimming or herbiciding. Recreational uses generally do not rely on vegetation removal to be carried out, except for trail maintenance; and vegetation management techniques including herbicides would not likely interfere with existing recreational uses. The herbicides would be applied from the ground using a truck-mounted sprayer, backpack sprayer, hand equipment, or ATV sprayer. These measures would not require closure of treated areas. Recreationists would maintain access and continue to use recreation areas, and potential impacts on the quality of the recreational experience, including noise-related effects, would be minor.

> **Impact LU-5:** Vegetation management would not appreciably impact the quantity and/or quality of recreational opportunities in the Program Area. This impact is **less than significant** and no mitigation is required.

Conflict with Applicable Land Use Regulations and Policies

This alternative does involve the potential use of herbicides primarily to facilitate access for vector surveillance and control, control vectors through habitat management/source reduction and, therefore, could be inconsistent with local ordinances restricting pesticide use when those ordinances apply to herbicide use. Most of the local pesticide ordinances include herbicides in their definition of pesticides. However, state law preempts local restrictions on the use of pesticides, local ordinances prohibiting their use on public property are not directly applicable to the Program. The limited use of herbicides is not inconsistent with Marin County's IPM policies, which are contained in its Countywide Plan.

> **Impact LU-6:** Vegetation management would not be inconsistent with applicable land use regulations. **No impact** would occur.

3.2.6 Biological Control Alternative

Impacts on Recreational Land Uses

The Biological Control Alternative entails the use of pathogens and predators to control target vectors. Mosquito pathogens are covered under the Chemical Control Alternative. The predator technique requires placement of mosquitofish in controlled water bodies such as ornamental ponds and water gardens. Such

methods would not be noticeable in recreational settings and would not likely interfere with existing recreational uses. Recreationists would maintain access and continue to use recreation areas as they do under existing conditions, and potential impacts on the quality of the recreational experience would be negligible.

> **Impact LU-7:** Biological control of vectors would not appreciably impact the quantity and/or quality of recreational opportunities in the Program Area. **No impact** would occur.

Conflict with Applicable Land Use Regulations and Policies

This alternative does not involve alterations to land uses and does not include the use of chemical pesticides to control vectors. Therefore, it would not be inconsistent with local ordinances regulating land uses or restricting pesticide use.

> **Impact LU-8:** Biological control of vectors would not be inconsistent with applicable land use regulations. **No impact** would occur.

3.2.7 Chemical Control Alternative

Impacts on Recreational Land Uses

The Chemical Control Alternative entails the periodic use of insecticides to control target vectors, which would be implemented based on a number of factors, including but not limited to the vector's abundance, density, species composition, proximity to human settlements, water temperature, and presence of predators. Chemical applications routinely occur in agricultural areas by farmers for crop production, so District applications for vector control would not conflict with local land use regulations. The District may apply chemicals in public recreation areas, such as parks and refuges, thereby potentially affecting recreational uses.[2] Chemical applications in recreation areas would improve the quality of recreational opportunities due to the elimination of impacts from vectors (e.g. biting). However, some factors may result in adverse effects on recreation. First, chemical application techniques may involve the use of heavy equipment, including aircraft for aerial applications, which would diminish the quality of the recreational experience realized by recreationists. Such equipment generates noise, particularly aircraft, and alters the visual landscape, which is inconsistent with the overall character of many recreation areas. Second, the potential exists that chemical applications would deter people from recreating in certain areas in an effort to avoid direct exposure, thereby limiting recreational access for local residents and visitors. The public education component of the Proposed Program (with BMPs A12 and H13) calls for public notification in advance of chemical application in public areas (including notification of recreation area managers as necessary for large-scale activities involving aircraft, ATVs, and airboat), which would allow recreationists to adjust their recreational patterns, e.g., visiting alternative recreation sites in the region. Together, potential impacts on recreational quality from the use of heavy equipment in public areas and impacts on recreational access from deterred visitors would generate impacts on recreational land uses in the Program Area. However, chemical applications in recreation areas would be isolated events similar to existing conditions and implemented on an as-needed basis; therefore, impacts on recreation would be temporary.

> **Impact LU-9:** Chemical application to control vectors would impact recreational access and the quality of recreational opportunities in the Program Area. However, because these impacts would be isolated and short term and would involve public notification for the large events in close proximity to recreation intensive use areas, they are considered **less than significant** and no mitigation is required.

[2] Table 3-1 shows the extent of federal land holdings in the Program Area, which include areas used for recreational purposes.

Conflict with Applicable Land Use Regulations and Policies

The Chemical Control Alternative could be inconsistent with local land use regulations that restrict pesticide use in some jurisdictions, such as those outlined in Section 3.1.3.3. However, state law preempts local restrictions on the use of pesticides; local ordinances prohibiting their use mostly on public land are not directly applicable to the Program. The use of pesticides under the District's IVMP based on IPM principles is not inconsistent with Marin County's IPM policies and those of cities and towns with IPM policies and exemptions for use of pesticides to protect public health and safety.

> **Impact LU-10:** The Chemical Control Alternative would not be inconsistent with applicable land use regulations because state law preempts local ordinances. **No impact** would occur.

3.2.8 Other Nonchemical Control/Trapping Alternative

Impacts on Recreational Land Uses

The Other Nonchemical Control/Trapping Alternative involves the use of traps to control vectors. Although such traps may be placed in recreational settings, they would not be directly placed in high-use areas during the day and, therefore, would not likely interfere with existing recreational uses. Recreationists would maintain access and continue to use recreation areas, and potential impacts on the quality of the recreational experience, including noise--related effects, would be negligible.

> **Impact LU-11:** Trapping of vectors would not appreciably impact the quantity and/or quality of recreational opportunities in the Program Area. This impact is **less than significant** and no mitigation is required.

Conflict with Applicable Land Use Regulations and Policies

This alternative does not involve the use of chemical pesticides to control vectors and, therefore, would not conflict with local ordinances restricting pesticide use.

> **Impact LU-12:** Other nonchemical control and trapping of vectors would not conflict with applicable land use regulations. **No impact** would occur.

3.2.9 Cumulative Impacts

See Section 13.1 for a complete discussion of cumulative impacts including a definition of what constitutes a significant cumulative impact. In summary, due to the extensive recreational opportunities on public lands within the Program Area (i.e., no existing significant cumulative impact within the Program Area), the small incremental potential impacts on recreational opportunities from five of the Proposed Program alternatives when combined would not likely cumulatively contribute to recreational impacts in the region. **No cumulative significant impacts to urban and rural land uses** are anticipated when all of the Program's incremental impacts and the impacts of other activities in the region are considered together.

3.2.10 Environmental Impacts Summary

Table 3-2 presents a summary of impacts related to land use including recreational opportunities and applicable land use regulations.

Table 3-2 Summary of Land Uses Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Effects on Land Uses						
Impact LU-1: Surveillance of vectors would not appreciably impact the quantity and/or quality of recreational opportunities in the Program Area. This impact is **less than significant** and no mitigation is required.	LS	na	na	na	na	na
Impact LU-2: Surveillance of vectors would not be inconsistent with applicable land use regulations**. No impact** would occur.	N	na	na	na	na	na
Impact LU-3: Physical control of vector habitat would not appreciably impact the quantity and/or quality of recreational opportunities in the Program Area. This impact is **less than significant** and no mitigation is required.	na	LS	na	na	na	na
Impact LU-4: Physical control of vectors would not be inconsistent with applicable land use regulations**. No impact** would occur.	na	N	na	na	na	na
Impact LU-5: Vegetation management would not appreciably impact the quantity and/or quality of recreational opportunities in the Program Area. This impact is **less than significant** and no mitigation is required.	na	na	LS	na	na	na
Impact LU-6: Vegetation management would not be inconsistent with applicable land use regulations**. No impact** would occur.	na	na	N	na	na	na
Impact LU-7: Biological control of vectors would not appreciably impact the quantity and/or quality of recreational opportunities in the Program Area. **No impact** would occur.	na	na	na	N	na	na
Impact LU-8: Biological control of vectors would not be inconsistent with applicable land use regulations**. No impact** would occur.	na	na	na	N	na	na
Impact LU-9: Chemical application to control vectors would impact recreational access and the quality of recreational opportunities in the Program Area. However, because these impacts would be isolated and short term and would involve public notification for the large events in close proximity to recreation intensive use areas, they are considered **less than significant** and no mitigation is required.	na	na	na	na	LS	na

Table 3-2 Summary of Land Uses Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact LU-10: The Chemical Control Alternative would not be inconsistent with applicable land use regulations because state law preempts local ordinances**. No impact** would occur.	na	na	na	na	N	na
Impact LU-11: Trapping of vectors would not appreciably impact the quantity and/or quality of recreational opportunities in the Program Area. This impact is **less than significant** and no mitigation is required.	na	na	na	na	na	LS
Impact LU-12: Other nonchemical control and trapping of vectors would not conflict with applicable land use regulations. **No impact** would occur.	na	na	na	na	na	N

LS = Less-than-significant impact

N = No impact

na = Not applicable

SM = Potentially significant but mitigable impact

SU = Significant and unavoidable impact

3.2.11 Mitigation and Monitoring

No mitigation or monitoring is required as it relates to land use.

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4 Biological Resources – Aquatic

This chapter evaluates the potential impacts of the Program alternatives on aquatic resources. These results are provided at a programmatic level. Section 4.1, Environmental Setting, presents an overview of the aquatic resources in the Program Area and vicinity.

Section 4.2, Environmental Impacts and Mitigation Measures, presents the following:

> Environmental concerns and evaluation criteria to determine whether the Program alternatives would cause significant impacts to aquatic resources

> Evaluation methods and assumptions

> Discussion of the impacts from the Program alternatives, and recommendations for mitigation, if required, for those impacts

> Cumulative impacts

> A summary of environmental impacts

This chapter depends heavily on the information provided in Appendix A, *Biological Resources Technical Report*, Appendix B, *Human and Ecological Health Assessment Report*, and Chapter 6, Ecological Health. Terrestrial resources are addressed in Chapter 5, Biological Resources - Terrestrial.

4.1 Environmental Setting

Section 4.1.1 identifies the zoogeographic provinces in the Marin/Sonoma Mosquito and Vector Control District's (District) Program Area, Section 4.1.2 describes the special-status aquatic species that have the potential to occur within the Program Area, and Section 4.1.3 provides an overview of federal, state, and local ordinances and regulations pertinent to these resources that are applicable to the Program. Section 4.1.4 identifies the Habitat Conservation Plans (HCCPs) and Natural Community Conservation Plans (NCCPs) in the Program Area. Special-status species are those that are listed as endangered, threatened, or candidate species under the federal Endangered Species Act, endangered or threatened under the California Endangered Species Act, or listed as species of special concern by the State of California.

4.1.1 Aquatic and Wetland Resources within the Program Area

The Program will be implemented within the District, located in Marin and Sonoma counties. The Program Area addressed in this PEIR also includes the four adjacent counties of Mendocino, Lake, Napa, and Solano. This area encompasses a range of aquatic habitats and a diverse array of fish, amphibians, aquatic reptiles, and other species that live a substantial portion of their lives in the water and breed in aquatic environments. Birds and mammals are included as terrestrial species and discussed in Chapter 5. The six Program Area counties where activities and treatments would be implemented are shown on Figure 4-1. The zoogeographic provinces are described in Appendix A.

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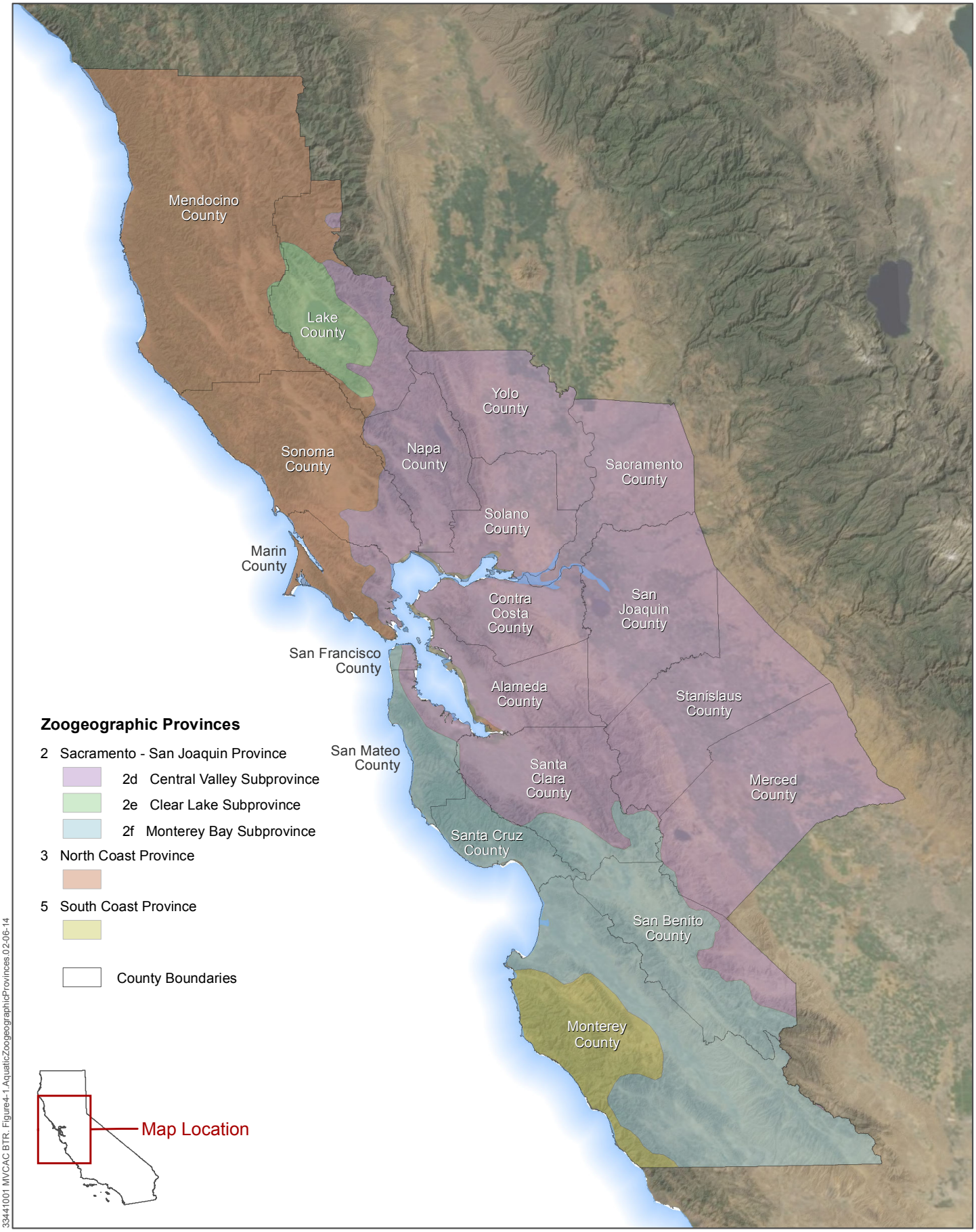

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0 20 40

Scale in Miles

Source: Chris Mari van Dyck, 2000

INTEGRATED VECTOR MANAGEMENT PROGRAM

Aquatic Zoogeographic Provinces

Figure 4-1

To facilitate the evaluation of impacts and impact avoidance measures by habitat type, a consistent set of habitat types was developed for wetland areas (Table 4-1). Wetland habitat types were based on those developed as part of the Bayland Ecosystem Habitat Goals Project (Goals Project 1999). To better capture the habitats potentially affected by the Program alternatives, habitat types from both the Goals Project and the San Francisco Estuary Project are used, as reflected in the Goals Project document (1999). Marine/Brackish Open Water and Tidal Flat habitat types defined in the San Francisco Bay system would not be treated under the Program and are not discussed further in this document. The last two categories in the table are artificial habitats that were not addressed in the Goals Project, but are important for consideration in the PEIR impact evaluations. In the case of Artificial Containers, Temporary Standing Waters and Ornamental Ponds, these habitats would not be expected to support special-status species. Within the Water and Wastewater Management category, water treatment facilities and onsite wastewater treatment (septic) systems would not be expected to support substantial populations of special-status species, but water discharged from these facilities may support special-status species in downstream or downgradient areas. These species may move into these facilities from adjacent wetlands and waterways. Flood channels and ditches may provide seasonal habitat for special-status species depending on the length of time these channels carry water and the characteristics of these channels.

Table 4-1 Aquatic and Wetland Habitat Types

Creeks and Rivers	Areas of flowing freshwater, although most downstream reaches may be influenced by tides.
Riparian Corridor	The trees, shrubs and other vegetation that grow along the edges of creeks and rivers. This vegetation is typically dependent on water from the river and forms an ecotone between the river and the surrounding uplands. May extend to broader riparian forest, where such exist.
Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	Areas of still water that typically remain wet throughout the year.
FW Marsh/Seeps	Freshwater areas that support reeds, rushes and other vegetation typical of wetlands.
Seasonal Wetlands (includes Vernal Pools)	Areas that support standing water for part of the year, but dry out during the summer months.
Lagoon	Area behind the mouth of a river or stream that has been closed off by sand or other material, but is at least sporadically subject to tidal action.
Tidal Marsh and channels	Vegetated wetland area subject to tidal action. Occurs along San Pablo Bay and Carquinez Strait. Includes both salt and brackish marshes. Includes tidal channels that carry water into and away from the marsh during the tidal cycle.
Tidal Flats	Mud flats exposed during low tide that do not hold water throughout the day and do not support substantial vegetation. Occurs between MLLW and Mean Tide Level (MTL).
Open Water (Marine/Brackish)	Continuously inundated areas of San Pablo Bay and Carquinez Strait area. Exposed to current and wave action. Occurs below Mean Lower Low Water (MLLW).
Water and Wastewater Management Facilities	Constructed channels, ponds and other facilities designed for the management of water or wastewater. May include natural or artificial bottoms. Includes flood control channels, agricultural and roadside ditches, retention basins, treatment ponds, winery waste ponds, wastewater treatment facilities, septic systems and all associated facilities.
Artificial Containers, Temporary Standing Waters and Ornamental Ponds	Artificial habitats that have little likelihood of supporting native plants and wildlife, including pots, ornamental ponds, tires, stormwater retention basins.

Source: Goals Project 1999

Each of these habitat types may be affected by one or more of the Program alternatives, as indicated in Table 4-2. The Program alternatives are described in Chapter 2 and the BMPs that would be applied to avoid and minimize potential impacts are provided in Table 2-6 (and repeated herein in Table 4-6 by habitat type).

Table 4-2 Wetland and Aquatic Habitat Types Potentially Affected by each Program Alternative

	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical Control/Trapping
Creeks and Rivers	X	X	X		X	
Riparian Corridor	X		X		X	X
Ponds and Lakes	X	X	X		X	
FW Marsh/Seeps	X	X	X		X	
Seasonal Wetlands (includes Vernal Pools)	X	X	X		X	
Lagoon	X	X	X			
Tidal Marsh and channels	X	X	X		X	
Water and Wastewater Management Facilities	X	X	X	X[1]	X	X
Artificial Containers, Temporary Standing Waters and Artificial Ponds	X	X	X	X[1]	X	

[1] Biological controls would not be applied in natural or artificial water bodies capable of supporting the breeding or aquatic rearing of California red-legged frog or California a tiger salamander. CRLF prefer still water, more than 0.7 m deep, bounded by dense shrubby vegetation (will, cattails and bulrush; Jennings and Haynes 1994). Tiger salamander are a lowland species (<200 ft msl) that breed in rain pools or vernal pools (lasting more than 10 weeks), that lack fish or bullfrog predators. Although historical breeding habitat for California tiger salamanders is natural vernal pools and ponds, they also use modified ephemeral or permanent ponds and manmade features such as constructed ponds or livestock ponds and have been reported in roadside ditches containing areas of seasonal wetlands. (USFWS 2014). Typically, breeding pools have moderate to high levels of turbidity. California tiger salamanders rarely use ponds with clear water. These locations must be within 1.6 km (1 mile) of suitable upland habitat, which consists of small mammal burrows, where juveniles and adults live and grow. If there is doubt whether a specific area would support breeding or aquatic rearing of these species, the District would contact the regulatory agencies prior to employing this alternative.

4.1.2 Special-Status Species

A number of special-status species are found in the Program Area and vicinity. Plant species are listed for the District in Table 4-3, while animal species are listed in Table 4-4. These tables also show the habitat types these species are likely to use. Because some species occur in both wetland and upland habitat types, all habitat types are included in this table. Upland habitat types are described in Chapter 5.

Table 4-3 California Natural Diversity Database Occurrences Plant Species in Marin/Sonoma Mosquito and Vector Control District and its Adjacent Program Area

Species Name	Status	Habitat	MSMVCD	MSMVCD Adjacent Counties	Conifer Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Tree Holes	Tidal Marsh and Channels	Lagoon	Creeks and Rivers	Ponds and Lakes	Seasonal Wetlands (includes Vernal Pools)	FW Marsh/Seeps	Riparian Forest	Temporary Standing Waters and Artificial Ponds	Wastewater Treatment Facilities/Septic Systems
pink sand-verbena *Abronia umbellata* var. *breviflora*	1B.1	Coastal dunes and coastal strand. Foredunes and interdunes with sparse cover. Abronia umbellata var. Breviflora is usually the plant closest to the ocean. 0-12 m.	X	X						X										
Blasdale's bent grass *Agrostis blasdalei*	1B.2	Coastal dunes and coastal strand. Foredunes and interdunes with sparse cover. Abronia umbellata var. Breviflora is usually the plant closest to the ocean. 0-12 m.	X	X						X										
Henderson's bent grass *Agrostis hendersonii*	3.2	Coastal dunes and coastal strand. Foredunes and interdunes with sparse cover. Abronia umbellata var. Breviflora is usually the plant closest to the ocean. 0-12 m.		X						X										
grass alisma *Alisma gramineum*	2B.2	Coastal dunes and coastal strand. Foredunes and interdunes with sparse cover. Abronia umbellata var. Breviflora is usually the plant closest to the ocean. 0-12 m.		X						X										
Franciscan onion *Allium peninsulare* var. *franciscanum*	1B.2	Coastal dunes and coastal strand. Foredunes and interdunes with sparse cover. Abronia umbellata var. Breviflora is usually the plant closest to the ocean. 0-12 m.	X	X						X										
Sonoma alopecurus *Alopecurus aequalis* var. *sonomensis*	FE, 1B.1	Coastal dunes and coastal strand. Foredunes and interdunes with sparse cover. Abronia umbellata var. Breviflora is usually the plant closest to the ocean. 0-12 m.	X							X										
Napa false indigo *Amorpha californica* var. *napensis*	1B.2	Coastal dunes and coastal strand. Foredunes and interdunes with sparse cover. Abronia umbellata var. Breviflora is usually the plant closest to the ocean. 0-12 m.	X	X						X										
bent-flowered fiddleneck *Amsinckia lunaris*	1B.2	Coastal dunes and coastal strand. Foredunes and interdunes with sparse cover. Abronia umbellata var. Breviflora is usually the plant closest to the ocean. 0-12 m.	X	X						X										
scabrid alpine tarplant *Anisocarpus scabridus*	1B.3	Coastal dunes and coastal strand. Foredunes and interdunes with sparse cover. Abronia umbellata var. Breviflora is usually the plant closest to the ocean. 0-12 m.		X						X										
slender silver moss *Anomobryum julaceum*	4.2	Broadleafed upland forest, lower montane coniferous forest, north coast coniferous forest. Moss which grows on damp rocks and soil; acidic substrates. Usually seen on roadcuts. 100-1000 m.	X		X	X														
dimorphic snapdragon *Antirrhinum subcordatum*	4.3	Chaparral, lower montane coniferous forest. Generally on serpentine or shale in foothill woodland or chaparral on S- and W-facing slopes. 185-800 m.		X	X		X		X											
McDonald's rockcress *Arabis macdonaldiana*	FE, SE, 1B.1	Lower montane coniferous forest, upper montane coniferous forest. Rocky outcrops, ridges, slopes, and flats on serpentine. 135-1455 m.		X	X				X											

Table 4-3 California Natural Diversity Database Occurrences Plant Species in Marin/Sonoma Mosquito and Vector Control District and its Adjacent Program Area

Species Name	Status	Habitat	MSMVCD	MSMVCD Adjacent Counties	Conifer Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Tree Holes	Tidal Marsh and Channels	Lagoon	Creeks and Rivers	Ponds and Lakes	Seasonal Wetlands (includes Vernal Pools)	FW Marsh/Seeps	Riparian Forest	Temporary Standing Waters and Artificial Ponds	Wastewater Treatment Facilities/Septic Systems
Baker's manzanita *Arctostaphylos bakeri* ssp. *bakeri*	1B.1	Broadleafed upland forest, chaparral. Entire species State-listed Rare. Often on serpentine. This is the State-listed Rare taxon, also known as A. Bakeri in Title 14. 75-230 m.	X			X	X		X											
The Cedars manzanita *Arctostaphylos bakeri* ssp. *sublaevis*	1B.2	Chaparral, closed-cone coniferous forest. Entire species listed state rare. In serpentine chaparral and sargent cypress woodland; typically in canyons and on slopes. 275-600 m.	X		X		X		X											
Sonoma canescent manzanita *Arctostaphylos canescens* ssp. *sonomensis*	1B.2	Chaparral, lower montane coniferous forest. Sometimes found on serpentine. 180-1675 m.	X	X	X		X		X											
Vine Hill manzanita *Arctostaphylos densiflora*	SE, 1B.1	Chaparral. Acid marine sand. 50-100 m.	X				X													
Konocti manzanita *Arctostaphylos manzanita* ssp. *elegans*	1B.3	Chaparral, cismontane woodland, lower montane coniferous forest. Volcanic soils. 395-1400 m.	X	X	X	X	X													
Mt. Tamalpais manzanita *Arctostaphylos montana* ssp. *montana*	1B.3	Chaparral, valley, and foothill grassland. Serpentine slopes in chaparral and grassland. 160-760 m.	X				X	X	X											
pygmy manzanita *Arctostaphylos nummularia* ssp. *mendocinoensis*	1B.2	Closed-cone coniferous forest. Acidic, sandy-clay soils in dwarf coniferous forest. 90-200 m.		X	X															
Rincon Ridge manzanita *Arctostaphylos stanfordiana* ssp. *decumbens*	1B.1	Chaparral. Highly restricted endemic to red rhyolites in Sonoma county. 75-310 m.	X	X			X													
Raiche's manzanita *Arctostaphylos stanfordiana* ssp. *raichei*	1B.1	Chaparral, lower montane coniferous forest. On periphery of McNab cypress grove on serpentine. Slopes and ridges. 450-1000 m.		X	X		X		X											
Marin manzanita *Arctostaphylos virgata*	1B.2	Broadleafed upland forest, closed-cone coniferous forest, chaparral, north coast coniferous forest. Only known from about 20 eos in Marin County. On sandstone or granitic soil. 60-700 m.	X		X	X	X													
Humboldt milk-vetch *Astragalus agnicidus*	SE, 1B.1	Broadleafed upland forest, redwood forest. Disturbed openings in partially timbered forest lands; also along ridgelines; south aspects. 575-750 m.		X	X	X														

Table 4-3 California Natural Diversity Database Occurrences Plant Species in Marin/Sonoma Mosquito and Vector Control District and its Adjacent Program Area

Species Name	Status	Habitat	MSMVCD	MSMVCD Adjacent Counties	Conifer Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Tree Holes	Tidal Marsh and Channels	Lagoon	Creeks and Rivers	Ponds and Lakes	Seasonal Wetlands (includes Vernal Pools)	FW Marsh/Seeps	Riparian Forest	Temporary Standing Waters and Artificial Ponds	Wastewater Treatment Facilities/Septic Systems
Clara Hunt's milk-vetch *Astragalus claranus*	FE, ST, 1B.1	Cismontane woodland, valley and foothill grassland, chaparral. Open grassy hillsides, esp. On exposed shoulders in thin, volcanic clay soil moist in spring. 75-235 m.	X	X		X	X	X												
coastal marsh milk-vetch *Astragalus pycnostachyus* var. *pycnostachyus*	1B.2	Coastal dunes, coastal salt marshes. Mesic sites in dunes or along streams or coastal salt marshes. 0-30 m.	X							X		X					X			
Jepson's milk-vetch *Astragalus rattanii* var. *jepsonianus*	1B.2	Cismontane woodland, valley and foothill grassland, chaparral. Commonly on serpentine in grassland or openings in chaparral. 320-700 m.	X	X		X	X	X	X											
alkali milk-vetch *Astragalus tener* var. *tener*	1B.2	Alkali playa, valley, and foothill grassland, vernal pools. Low ground, alkali flats, and flooded lands; in annual grassland or in playas or vernal pools. 1-170 m.	X	X				X								X				
San Joaquin spearscale *Atriplex joaquinana*	1B.2	Chenopod scrub, alkali meadow, valley and foothill grassland. In seasonal alkali wetlands or alkali sink scrub with distichlis spicata, frankenia, etc. 1-250 m.		X			X	X												
big-scale balsamroot *Balsamorhiza macrolepis*	1B.2	Valley and foothill grassland, cismontane woodland. Sometimes on serpentine. 35-1000 m.	X	X		X		X	X											
Sonoma sunshine *Blennosperma bakeri*	FE, SE, 1B.1	Vernal pools, valley and foothill grassland. Vernal pools and swales. 10-100 m.	X					X								X				
Point Reyes blennosperma *Blennosperma nanum* var. *robustum*	1B.2	Coastal prairie, coastal scrub. On open coastal hills in sandy soil. 10-145 m.	X	X			X	X												
Snow Mountain rockcress *Boechera ultraalsa*	1B.1	Upper montane coniferous forest. Rocky sites. 1800 m.		X	X															
rattlesnake fern *Botrypus virginianus*	2B.2	Bogs and fens, lower montane coniferous forest, meadows and seeps, riparian forest. 715-1355 m.		X	X												X	X		
watershield *Brasenia schreberi*	2B.3	Freshwater marshes and swamps. Aquatic from water bodies both natural and artificial in California.		X													X			
narrow-anthered brodiaea *Brodiaea leptandra*	1B.2	Broadleafed upland forest, chaparral, lower montane coniferous forest. 110-915 m.	X	X	X	X														
Indian Valley brodiaea *Brodiaea rosea*	SE, 1B.1	Closed-cone coniferous forest, chaparral, cismontane woodland, valley and foothill grassland, meadows. Serpentine gravelly creek bottoms, and in meadows and swales. 335-1450 m.		X	X	X		X	X											

Table 4-3 California Natural Diversity Database Occurrences Plant Species in Marin/Sonoma Mosquito and Vector Control District and its Adjacent Program Area

Species Name	Status	Habitat	MSMVCD	MSMVCD Adjacent Counties	Conifer Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Tree Holes	Tidal Marsh and Channels	Lagoon	Creeks and Rivers	Ponds and Lakes	Seasonal Wetlands (includes Vernal Pools)	FW Marsh/Seeps	Riparian Forest	Temporary Standing Waters and Artificial Ponds	Wastewater Treatment Facilities/Septic Systems
Thurber's reed grass *Calamagrostis crassiglumis*	2B.1	Coastal scrub, freshwater marsh. Usually in marshy swales surrounded by grassland or coastal scrub. 10-45 m.	X	X			X	X									X			
leafy reed grass *Calamagrostis foliosa*	4.2	Coastal bluff scrub, north coast coniferous forest. Rocky cliffs and ocean-facing bluffs. 0-1220 m. State-listed rare. Element occurrences archived; CNPS list 4.		X	X		X													
round-leaved filaree *California macrophylla*	1B.1	Cismontane woodland, valley and foothill grassland. Clay soils. 15-1200 m.	X	X		X		X												
The Cedars fairy-lantern *Calochortus raichei*	1B.2	Closed-cone coniferous forest, chaparral. On serpentine. Usually on shaded slopes, but also on barrens and talus. 200-490 m.	X		X		X		X											
Tiburon mariposa-lily Calochortus tiburonensis	FT, ST, 1B.1	Valley and foothill grassland. On open, rocky, slopes in serpentine grassland. 50-150 m.	X					X	X											
small-flowered calycadenia *Calycadenia micrantha*	1B.2	Chaparral, valley and foothill grassland, meadows and seeps, lower montane coniferous forest. Rocky talus or scree; sparsely vegetated areas. Occasionally on roadsides; sometimes on serpentine. 5-1500 m.		X	X		X	X	X								X			
Butte County morning-glory *Calystegia atriplicifolia* ssp. *buttensis*	4.2	Lower montane coniferous forest. Dry, mostly open slopes. 600-1200 m.		X	X															
Mt. Saint Helena morning-glory *Calystegia collina* ssp. *oxyphylla*	4.2	Chaparral, lower montane coniferous forest, valley and foothill grassland. On serpentine barrens, slopes, and hillsides. 280-1010 m.	X	X	X		X	X	X											
coast range bindweed *Calystegia collina* ssp. *tridactylosa*	1B.2	Chaparral, cismontane woodland. Rocky, gravelly openings in serpentine. 0-600 m.		X		X	X		X											
coastal bluff morning-glory *Calystegia purpurata* ssp. *saxicola*	1B.2	Coastal dunes, coastal scrub. 15-105 m.	X	X			X			X										
swamp harebell *Campanula californica*	1B.2	Bogs and fens, closed-cone coniferous forest, coastal prairie, meadows, freshwater marsh, n coast coniferous forest. Bogs and marshes in a variety of habitats; uncommon where it occurs. 1-405 m.	X	X	X			X									X			
seaside bittercress *Cardamine angulata*	2B.1	North coast coniferous forest, lower montane coniferous forest. Wet areas, streambanks. 65-915 m.	X		X													X		

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California sedge *Carex californica*	2B.3	Bogs and fens, closed-cone coniferous forest, coastal prairie, meadows, marshes and swamps. Meadows, drier areas of swamps, marsh margins. 90-250 m.		X	X			X									X			
bristly sedge *Carex comosa*	2B.1	Marshes and swamps. Lake margins, wet places; site below sea level is on a delta island. -5-1005 m.	X	X											X		X			
porcupine sedge *Carex hystericina*	2B.1	Marshes and swamps. Wet places, such as stream edges. 610-915 m.		X													X	X		
Klamath sedge *Carex klamathensis*	1B.2	Meadows and seeps, chaparral, cismontane woodland. Serpentine. 1000-1140 m.		X			X	X	X								X			
lagoon sedge *Carex lenticularis* var. *limnophila*	2B.2	Bogs and fens, marshes and swamps, north coast coniferous forest. Lakeshores, beaches. 0-6 m.		X	X					X					X		X			
bristle-stalked sedge *Carex leptalea*	2B.2	Bogs and fens, meadows, marshes and swamps. Mostly known from bogs and wet meadows. 0-790 m.	X					X									X			
livid sedge *Carex livida*	2A	Bogs and fens. Historically known from a sphagnum bog in California. 120 m.		X													X			
Lyngbye's sedge *Carex lyngbyei*	2B.2	Marshes and swamps (brackish or freshwater). 0 m.	X	X													X			
deceiving sedge *Carex saliniformis*	1B.2	Coastal prairie, coastal scrub, meadows and seeps, marshes and swamps (coastal salt). Mesic sites. 3-230 m.	X	X			X	X									X			
green yellow sedge *Carex viridula* ssp. *viridula*	2B.3	Bogs and fens, marshes and swamps (freshwater), north coast coniferous forest. Mesic sites. 0-1600 m.		X	X												X			
Tiburon paintbrush *Castilleja affinis* var. *neglecta*	FE, ST, 1B.2	Valley and foothill grassland. Rocky serpentine sites. 75-400 m.	X	X				X	X											
Humboldt Bay owl's-clover *Castilleja ambigua* var. *humboldtiensis*	1B.2	Coastal salt marsh. In coastal saltmarsh with spartina, distichlis, salicornia, jaumea. 0-3 m.	X	X								X								
Mead's owls-clover *Castilleja ambigua* var. *meadii*	1B.1	Vernal pools, meadows and seeps. Soils of volcanic origin and tend to have high clay content and be gravelly. 450-475 m.		X				X								X	X			
Point Reyes paintbrush *Castilleja leschkeana*	1A	Marshes and swamps (coastal). 0-10 m.	X														X			

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Oregon coast paintbrush *Castilleja litoralis*	2B.2	Coastal bluff scrub, coastal dunes, coastal scrub. Sandy sites. 15-100 m.		X			X			X										
Mendocino Coast paintbrush *Castilleja mendocinensis*	1B.2	Coastal bluff scrub, coastal scrub, coastal prairie, closed-cone coniferous forest, coastal dunes. Often on sea bluffs or cliffs in coastal bluff scrub or prairie. 0-160 m.	X	X	X		X	X		X										
pink creamsacs *Castilleja rubicundula* var. *rubicundula*	1B.2	Chaparral, meadows and seeps, valley and foothill grassland. Openings in chaparral or grasslands. On serpentine. 20-900 m.		X			X	X	X								X			
Pitkin Marsh paintbrush *Castilleja uliginosa*	SE, 1A	Freshwater marsh. Last known remaining plant died in 1987; was known from overgrown freshwater marsh. 60 m.	X														X			
Rincon Ridge ceanothus *Ceanothus confusus*	1B.1	Closed-cone coniferous forest, chaparral, cismontane woodland. Known from volcanic or serpentine soils, dry shrubby slopes. 75-1065 m.	X	X	X	X	X		X											
Calistoga ceanothus *Ceanothus divergens*	1B.2	Chaparral, cismontane woodland. Rocky, serpentine, or volcanic sites. 165-950 m.	X	X		X	X		X											
Vine Hill ceanothus *Ceanothus foliosus* var. *vineatus*	1B.1	Chaparral. Sandy, acidic soil in chaparral. 45-85 m.	X				X													
Mt. Vision ceanothus *Ceanothus gloriosus* var. *porrectus*	1B.3	Closed-cone coniferous forest, coastal prairie, coastal scrub, valley and foothill grassland. Low shrub in a variety of habitats on pt. Reyes; sandy soils. 25-305 m.	X		X		X	X												
Mason's ceanothus *Ceanothus masonii*	1B.2	Chaparral. Serpentine ridges or slopes in chaparral or transition zone. 230-500 m.	X				X		X											
holly-leaved ceanothus *Ceanothus purpureus*	1B.2	Chaparral. Rocky, volcanic slopes. 120-640 m.	X	X			X													
Sonoma ceanothus *Ceanothus sonomensis*	1B.2	Chaparral. Sandy, serpentine, or volcanic soils. 210-800 m.	X	X					X											
pappose tarplant *Centromadia parryi* ssp. *parryi*	1B.2	Coastal prairie, meadows and seeps, coastal salt marsh, valley and foothill grassland. Vernally mesic, often alkaline sites. 2-420 m.	X	X				X				X					X			
dwarf soaproot *Chlorogalum pomeridianum* var. *minus*	1B.2	Chaparral, valley and foothill grassland. Serpentine. 240-970 m.	X	X			X	X	X											

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Point Reyes salty bird's-beak *Chloropyron maritimum* ssp. *palustre*	1B.2	Cismontane woodland, valley and foothill grassland. Often in grassy areas with blue oaks in foothill woodland. 300-330 m.	X			X		X												
soft salty bird's-beak *Chloropyron molle* ssp. *molle*	FE, 1B.2	Coastal salt marsh. In coastal salt marsh with distichlis, salicornia, frankenia, etc. 0-3 m	X	X								X								
San Francisco Bay spineflower *Chorizanthe cuspidata* var. *cuspidata*	1B.2	Coastal bluff scrub, coastal dunes, coastal prairie, coastal scrub. Closely related to c. Pungens. Sandy soil on terraces and slopes. 5-550 m.	X				X	X		X										
woolly-headed spineflower *Chorizanthe cuspidata* var. *villosa*	1B.2	Coastal scrub, coastal dunes, coastal prairie. Sandy places near the beach. 3-60 m.	X				X	X		X										
Howell's spineflower *Chorizanthe howellii*	FE, ST, 1B.2	Coastal dunes, coastal prairie, coastal scrub. Sand dunes, sandy slopes, and sandy areas in coastal prairie. 0-35 m.		X				X		X										
robust spineflower *Chorizanthe robusta* var. *robusta*	FE, 1B.1	Cismontane woodland, coastal dunes, coastal scrub. Sandy terraces and bluffs or in loose sand. 3-120 m.	X			X	X			X										
Sonoma spineflower *Chorizanthe valida*	FE, SE, 1B.1	Coastal prairie. Sandy soil. 10-50 m.	X					X												
Bolander's water-hemlock *Cicuta maculata* var. *bolanderi*	2B.1	Marshes, fresh or brackish water. 0-200 m.	X									X					X			
Franciscan thistle *Cirsium andrewsii*	1B.2	Coastal bluff scrub, broadleaved upland forest, coastal scrub. Sometimes serpentine seeps. 0-135 m.	X			X	X		X								X			
Mt. Tamalpais thistle *Cirsium hydrophilum* var. *vaseyi*	1B.2	Broadleafed upland forest, chaparral, meadows and seeps. Serpentine seeps and streams in chaparral and woodland. 240-620 m.	X			X	X	X	X					X			X			
Whitney's farewell-to-spring *Clarkia amoena* ssp. *whitneyi*	1B.1	Coastal bluff scrub, coastal scrub. 10-100 m.		X			X													
Raiche's red ribbons *Clarkia concinna* ssp. *raichei*	1B.1	Coastal bluff scrub. Highly exposed rocky bluffs with a near-vertical slope. 0-100 m.	X				X													
Vine Hill clarkia *Clarkia imbricata*	FE, SE, 1B.1	Chaparral, valley and foothill grassland. Acidic, sandy soil. 50-75 m.	X				X	X												

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round-headed Chinese-houses *Collinsia corymbosa*	1B.2	Coastal dunes. 0-20 m.		X						X										
San Francisco collinsia Collinsia multicolor	1B.2	Closed-cone coniferous forest, coastal scrub. On decomposed shale (mudstone) mixed with humus. 30-250 m.	X		X		X													
Oregon goldthread *Coptis laciniata*	2B.2	North coast coniferous forest, meadows and seeps. Mesic sites such as moist streambanks. 0-1000 m.		X	X			X						X			X			
Pennell's bird's-beak *Cordylanthus tenuis* ssp. *capillaris*	FE, 1B.2	Closed-cone coniferous forest, chaparral. In open or disturbed areas on serpentine within forest or chaparral. 45-230 m.	X		X		X		X											
bunchberry *Cornus canadensis*	2B.2	North coast coniferous forest, bogs and fens, meadows and seeps.		X	X												X			
serpentine cryptantha *Cryptantha dissita*	1B.2	Chaparral. Serpentine outcrops. 330-730 m.	X	X			X		X											
deep-scarred cryptantha *Cryptantha excavata*	1B.3	Cismontane woodland. Sandy, gravelly, dry streambanks. 100-500 m.		X		X														
Jepson's dodder *Cuscuta jepsonii*	1B.2	North coast coniferous forest. Streamsides. 1200-2300 m.		X	X									X						
Peruvian dodder *Cuscuta obtusiflora* var. *glandulosa*	2B.2	Marshes and swamps (freshwater). Freshwater marsh. 15-280 m.	X														X			
Mendocino dodder *Cuscuta pacifica* var. *papillata*	1B.2	Coastal dunes. Interdune depressions. Annual parasitic vine observed on gnaphalium, silene and lupinus. 0-50 m.	X	X						X										
Baker's larkspur *Delphinium bakeri*	SE, 1B.1	Coastal scrub, grasslands. Only site occurs on nw-facing slope, on decomposed shale. Historically known from grassy areas along fencelines too. 90-205 m.	X				X	X												
golden larkspur *Delphinium luteum*	FE, 1B.1	Chaparral, coastal prairie, coastal scrub. North-facing rocky slopes. 0-100 m.	X				X	X												
western leatherwood *Dirca occidentalis*	1B.2	Broadleafed upland forest, chaparral, closed-cone coniferous forest, cismontane woodland, north coast coniferous forest, riparian forest, riparian woodland. On brushy slopes, mesic sites; mostly in mixed evergreen and foothill woodland communities. 30-550 m.	X		X	X	X											X		

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dwarf downingia *Downingia pusilla*	2B.2	Valley and foothill grassland (mesic sites), vernal pools. Vernal lake and pool margins with a variety of associates. In several types of vernal pools. 1-485 m.	X	X				X								X				
Koch's cord moss *Entosthodon kochii*	1B.3	Cismontane woodland, valley and foothill grasslands. Moss growing on soil on river banks. Known from serpentine on the plumas nf. 500-1000 m.	X	X		X		X	X					X						
Snow Mountain willowherb *Epilobium nivium*	1B.2	Upper montane coniferous forest, chaparral. In crevices of rocky outcrops, and dry talus and shale slopes. 785-2500 m.		X	X															
Oregon fireweed *Epilobium oreganum*	1B.2	Bogs and fens, meadows, lower montane coniferous forest, upper montane coniferous forest. In and near springs and bogs; at least sometimes on serpentine. 500-2610 m.		X	X			X	X								X			
Brandegee's eriastrum *Eriastrum brandegeeae*	1B.1	Chaparral, cismontane woodland. On barren volcanic soils; often in open areas. 425-840 m.		X		X	X													
Tracy's eriastrum *Eriastrum tracyi*	3.2	Chaparral, cismontane woodland. Gravelly shale or clay; often in open areas. 315-760 m.		X		X	X													
Greene's narrow-leaved daisy *Erigeron greenei*	1B.2	Chaparral. Serpentine and volcanic substrates, generally in shrubby vegetation. 75-1060 m.	X	X			X		X											
serpentine daisy *Erigeron serpentinus*	1B.3	Chaparral. Serpentine seeps. 60-670 m.	X				X		X											
supple daisy *Erigeron supplex*	1B.2	Coastal bluff scrub, coastal prairie. Usually in grassy sites. 10-50 m.	X	X			X	X												
The Cedars buckwheat *Eriogonum cedrorum*	1B.3	Closed-cone coniferous forest. Serpentine. Barren rock and talus steep slopes. 365-550 m.	X		X				X											
Kellogg's buckwheat *Eriogonum kelloggii*	SE, 1B.2	Lower montane coniferous forest, chaparral. Rocky, serpentine sites. 925-1220 m.		X	X		X		X											
Tiburon buckwheat *Eriogonum luteolum* var. *caninum*	1B.2	Chaparral, valley and foothill grassland, cismontane woodland, coastal prairie. Serpentine soils; sandy to gravelly sites. 0-700 m.	X			X	X	X	X											
Snow Mountain buckwheat *Eriogonum nervulosum*	1B.2	Chaparral. Dry serpentine outcrops, balds, and barrens. 300-2100 m.	X	X			X		X											
Loch Lomond button-celery *Eryngium constancei*	FE, SE, 1B.1	Vernal pools. Volcanic ash flow vernal pools. 625-855 m.	X	X												X				

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bluff wallflower *Erysimum concinnum*	1B.2	Coastal dunes, coastal bluff scrub, coastal prairie. More or less a coastal generalist within coastal habitat types. 0-185 m.	X	X			X	X		X										
Menzies' wallflower *Erysimum menziesii*	FE, SE, 1B.1	Coastal dunes. Localized on dunes and coastal strand. 0-35 m.		X						X										
coast fawn lily *Erythronium revolutum*	2B.2	Bogs and fens, broadleafed upland forest, North Coast coniferous forest.		X	X	X											X			
minute pocket moss *Fissidens pauperculus*	1B.2	North coast coniferous forest. Moss growing on damp soil along the coast. In dry streambeds and on stream banks. 10-100 m.	X	X	X									X						
Marin checker lily *Fritillaria lanceolata* var. *tristulis*	1B.1	Coastal bluff scrub, coastal scrub, coastal prairie. Occurrences reported from canyons and riparian areas as well as rock outcrops; often on serpentine. 30-300 m.	X				X	X	X									X		
fragrant fritillary *Fritillaria liliacea*	1B.2	Coastal scrub, valley and foothill grassland, coastal prairie. Often on serpentine; various soils reported though usually clay, in grassland. 3-410 m.	X				X	X	X											
adobe-lily *Fritillaria pluriflora*	1B.2	Chaparral, cismontane woodland, foothill grassland. Usually on clay soils; sometimes serpentine. 55-820 m.		X		X	X	X	X											
Roderick's fritillary *Fritillaria roderickii*	SE, 1B.1	Coastal bluff scrub, coastal prairie, valley and foothill grassland. Grassy slopes, mesas. 15-610 m.	X	X			X	X												
Mendocino gentian *Gentiana setigera*	1B.2	Lower montane coniferous forest, meadows. Meadows, seeps and bogs. Usually or always on serpentine. 490-1065 m.		X	X			X	X								X			
blue coast gilia *Gilia capitata* ssp. *chamissonis*	1B.1	Coastal dunes, coastal scrub. 2-200 m.	X							X										
Pacific gilia *Gilia capitata* ssp. *pacifica*	1B.2	Coastal bluff scrub, coastal prairie, valley and foothill grassland. 5-300 m.	X	X			X	X												
woolly-headed gilia *Gilia capitata* ssp. *tomentosa*	1B.1	Coastal bluff scrub. Rocky outcrops on the coast. 15-155 m.	X				X													
dark-eyed gilia *Gilia millefoliata*	1B.2	Coastal dunes. 2-20 m.	X	X						X										
American manna grass *Glyceria grandis*	2B.3	Meadows. Wet meadows, ditches, streams, and ponds in valleys and lower elevations in the mountains. 15-1980 m.		X				X						X	X					

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Boggs Lake hedge-hyssop *Gratiola heterosepala*	SE, 1B.2	Marshes and swamps (freshwater), vernal pools. Clay soils; usually in vernal pools, sometimes on lake margins. 5-2400 m.	X	X											X	X	X			
Toren's grimmia *Grimmia torenii*	1B.3	Cismontane woodland, lower montane coniferous forest, chaparral. Openings, rocky, boulder and rock walls, carbonate, volcanic. 325-1160 m.		X	X	X	X													
Guggolz's harmonia *Harmonia guggolziorum*	1B.1	Chaparral. Open areas on serpentine. 160-195 m.		X			X		X											
Hall's harmonia *Harmonia hallii*	1B.2	Chaparral. Serpentine hills and ridges. Open, rocky areas within chaparral. 500-900 m.		X			X		X											
Diablo helianthella *Helianthella castanea*	1B.2	Broadleaved upland forest, chaparral, cismontane woodland, coastal scrub, riparian woodland, valley and foothill grassland. Usually in chaparral/oak woodland interface in rocky, azonal soils. Often in partial shade. 25-1150 m.	X			X	X	X												
white seaside tarplant *Hemizonia congesta* ssp. *congesta*	1B.2	Coastal scrub, valley and foothill grassland. Grassy valleys and hills, often in fallow fields. 25-200 m.	X	X			X	X												
short-leaved evax *Hesperevax sparsiflora* var. *brevifolia*	1B.2	Coastal bluff scrub, coastal dunes. Sandy bluffs and flats. 0-200 m.	X	X			X			X										
pygmy cypress *Hesperocyparis pygmaea*	1B.2	Closed-cone coniferous forest. On podzol-like blacklock soil in pygmy cypress forest community. 35-305 m.	X	X	X															
glandular western flax *Hesperolinon adenophyllum*	1B.2	Chaparral, cismontane woodland, valley and foothill grassland. Serpentine soils; generally found in sepentine chaparral. 425-1315 m.		X		X	X	X	X											
two-carpellate western flax *Hesperolinon bicarpellatum*	1B.2	Serpentine chaparral. Serpentine barrens at edge of chaparral. 150-820 m.	X	X			X		X											
Brewer's western flax *Hesperolinon breweri*	1B.2	Chaparral, cismontane woodland, valley and foothill grassland. Often in rocky serpentine soil in serpentine chaparral and serpentine grassland. 30-885 m.		X		X	X	X	X											
Marin western flax *Hesperolinon congestum*	FT, ST, 1B.1	Chaparral, valley and foothill grassland. In serpentine barrens and in serpentine grassland and chaparral. 30-365 m.	X				X	X	X											
Lake County western flax *Hesperolinon didymocarpum*	SE, 1B.2	Chaparral, cismontane woodland, valley and foothill grassland. Serpentine soil in open grassland and near chaparral. 330-365 m.		X		X	X	X	X											

Table 4-3 California Natural Diversity Database Occurrences Plant Species in Marin/Sonoma Mosquito and Vector Control District and its Adjacent Program Area

Species Name	Status	Habitat	MSMVCD	MSMVCD Adjacent Counties	Conifer Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Tree Holes	Tidal Marsh and Channels	Lagoon	Creeks and Rivers	Ponds and Lakes	Seasonal Wetlands (includes Vernal Pools)	FW Marsh/Seeps	Riparian Forest	Temporary Standing Waters and Artificial Ponds	Wastewater Treatment Facilities/Septic Systems
drymaria-like western flax *Hesperolinon drymarioides*	1B.2	Closed-cone coniferous forest, chaparral, cismontane woodland, valley and foothill grassland. Serpentine soils, mostly within chaparral. 390-1000 m.		X	X	X	X	X	X											
Sharsmith's western flax *Hesperolinon sharsmithiae*	1B.2	Chaparral. Serpentine substrates. 270-300 m.		X			X		X											
water star-grass *Heteranthera dubia*	2B.2	Marshes and swamps. Alkaline, still or slow-moving water. Requires a pH of 7 or higher, usually in slightly eutrophic waters. 30-1495 m.	X														X			
Santa Cruz tarplant *Holocarpha macradenia*	FT, SE, 1B.1	Coastal prairie, valley and foothill grassland. Light, sandy soil or sandy clay; often with nonnatives. 10-260 m.	X					X												
Bolander's horkelia *Horkelia bolanderi*	1B.2	Lower montane coniferous forest, chaparral, meadows, valley and foothill grassland. Grassy margins of vernal pools and meadows. 450-850 m.		X	X			X								X				
Kellogg's horkelia *Horkelia cuneata* var. *sericea*	1B.1	Closed-cone coniferous forest, coastal scrub, chaparral. Old dunes, coastal sandhills; openings. 10-200 m.	X		X		X			X										
Point Reyes horkelia *Horkelia marinensis*	1B.2	Coastal dunes, coastal prairie, coastal scrub. Sandy flats and dunes near coast; in grassland or scrub plant communities. 5-30 m.	X	X			X	X		X										
thin-lobed horkelia *Horkelia tenuiloba*	1B.2	Coastal scrub, chaparral. Sandy soils; mesic openings. 45-500 m.	X	X			X													
water howellia *Howellia aquatilis*	FT, 2B.2	Freshwater marshes and swamps, lower montane coniferous forest. In clear ponds with other aquatics and surrounded by ponderosa pine forest and sometimes riparian associates. 3-1375 m.		X	X										X		X	X		
Baker's globe mallow *Iliamna bakeri*	4.2	Chaparral, Great Basin scrub, pinyon juniper woodland, lower montane coniferous forest. Rocky loam or volcanic soils. 1000-2500 m.		X	X		X													
California satintail *Imperata brevifolia*	2B.1	Coastal scrub, chaparral, riparian scrub, Mojavean scrub, meadows and seeps (alkali). Mesic sites, alkali seeps, riparian areas. 0-500 m.		X			X	X										X			
Northern California black walnut *Juglans hindsii*	1B.1	Riparian forest, riparian woodland. Few extant native stands remain; widely naturalized. Deep alluvial soil associated with a creek or stream. 0-395 m.		X														X		
Santa Lucia dwarf rush *Juncus luciensis*	1B.2	Vernal pools, meadows, lower montane coniferous forest, chaparral, great basin scrub. Vernal pools, ephemeral drainages, wet meadow habitats and streamsides. 300-2040 m.		X	X		X	X							X	X					

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hair-leaved rush *Juncus supiniformis*	2B.2	Marshes and swamps, bogs and fens. 20-100 m.		X													X			
small groundcone *Kopsiopsis hookeri*	2B.3	North coast coniferous forest. Open woods, shrubby places, generally on gaultheria shallon. 90-885 m.	X	X	X		X													
Burke's goldfields *Lasthenia burkei*	FE, SE, 1B.1	Vernal pools, meadows and seeps. Most often in vernal pools and swales. 15-580 m.	X	X												X	X			
Baker's goldfields *Lasthenia californica* ssp. *bakeri*	1B.2	Closed-cone coniferous forest, coastal scrub. Openings. 60-520 m.	X	X	X		X													
perennial goldfields *Lasthenia californica* ssp. *macrantha*	1B.2	Coastal bluff scrub, coastal dunes, coastal scrub. 5-520 m.	X	X			X			X										
Contra Costa goldfields *Lasthenia conjugens*	FE, 1B.1	Valley and foothill grassland, vernal pools, cismontane woodland. Extirpated from most of its range; extreme. Endangered. Vernal pools, swales, low depressions, in open grassy areas. 1-445 m.	X	X		X		X								X				
Delta tule pea *Lathyrus jepsonii* var. *jepsonii*	1B.2	Freshwater and brackish marshes. Often found with typha, aster lentus, rosa calif., juncus spp., scirpus, etc. Usually on marsh and slough edges.	X	X								X					X			
marsh pea *Lathyrus palustris*	2B.2	Bogs and fens, lower montane coniferous forest, marshes and swamps, north coast coniferous forest, coastal prairie, coastal scrub. Moist coastal areas. 1-100 m.		X	X		X	X									X			
beach layia *Layia carnosa*	FE, SE, 1B.1	Coastal dunes. Hugely reduced in range along California's north coast dunes. On sparsely vegetated, semi-stabilized dunes, usually behind foredunes. 0-75 m.	X							X										
Colusa layia *Layia septentrionalis*	1B.2	Chaparral, cismontane woodland, valley and foothill grassland. Scattered colonies in fields and grassy slopes in sandy or serpentine soil. 145-1095 m.	X	X		X	X	X	X											
legenere *Legenere limosa*	1B.1	Vernal pools. Many historical occurrences are extirpated. In beds of vernal pools. 1-880 m.	X	X												X				
coast yellow leptosiphon *Leptosiphon croceus*	1B.1	Coastal bluff scrub, coastal prairie. 10-150 m.	X				X	X												
Jepson's leptosiphon *Leptosiphon jepsonii*	1B.2	Chaparral, cismontane woodland. Open to partially shaded grassy slopes. On volcanics or the periphery of serpentine substrates. 100-500 m.	X	X		X	X		X											

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rose leptosiphon *Leptosiphon rosaceus*	1B.1	Coastal bluff scrub. 0-100 m.	X				X													
Crystal Springs lessingia *Lessingia arachnoidea*	1B.2	Coastal sage scrub, valley and foothill grassland, cismontane woodland. Grassy slopes on serpentine; sometimes on roadsides. 60-200 m.	X			X	X	X	X											
Tamalpais lessingia *Lessingia micradenia* var. *micradenia*	1B.2	Chaparral, valley and foothill grassland. Usually on serpentine, in serpentine grassland or serpentine chaparral. Often on roadsides. 100-305 m.	X				X	X	X											
Stebbins' lewisia *Lewisia stebbinsii*	1B.2	Upper montane coniferous forest, lower montane coniferous forest. Relatively barren exposed ridges and slopes in nutrient poor soils (mostly serpentine). 1680-2050 m.		X	X				X											
Mason's lilaeopsis *Lilaeopsis masonii*	1B.1	Freshwater and brackish marshes, riparian scrub. Tidal zones, in muddy or silty soil formed through river deposition or river bank erosion. 0-10 m.	X	X								X		X			X	X		
coast lily *Lilium maritimum*	1B.1	Closed-cone coniferous forest, coastal prairie, coastal scrub, broadleaved upland forest, north coast coniferous forest. Historically in sandy soil, often on raised hummocks or bogs; today mostly in roadside ditches. 10-335 m.	X	X	X	X	X													
Pitkin Marsh lily *Lilium pardalinum* ssp. *pitkinense*	FE, SE	Cismontane woodland, meadows and seeps, freshwater marsh. Saturated, sandy soils with grasses and shrubs. 35-65 m.	X			X		X									X			
Baker's meadowfoam *Limnanthes bakeri*	1B.1	Freshwater marsh, valley and foothill grassland, meadows and seeps, vernal pools. Seasonally moist or saturated sites within grassland; also in swales, roadside ditches and margins of marshy areas. 175-910 m.		X				X								X	X			
Point Reyes meadowfoam *Limnanthes douglasii* ssp. *sulphurea*	SE, 1B.2	Fresh. Marsh, vernal pools, coastal prairie, meadows and seeps, cismontane woodland. Vernally wet depressions in open rolling, coastal prairies and meadows; typically in dark clay soil. 10-120 m.	X			X		X								X	X			
woolly meadowfoam *Limnanthes floccosa* ssp. *floccosa*	4.2	Chaparral, cismontane woodland, valley and foothill grassland, vernal pools. Vernally wet areas, ditches, and ponds. 60-1335 m.		X		X	X	X								X				
Sebastopol meadowfoam *Limnanthes vinculans*	FE, SE, 1B.1	Mesic meadows, vernal pools, valley and foothill grassland. Swales, wet meadows and marshy areas in valley oak savanna; on poorly drained soils of clays and sandy loam. 15-115 m.	X	X				X								X				

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Anthony Peak lupine *Lupinus antoninus*	1B.3	Upper montane coniferous forest, lower montane coniferous forest. Open areas with surrounding forest; rocky sites. 1210-2285 m.		X	X															
Milo Baker's lupine *Lupinus milo-bakeri*	ST, 1B.1	Cismontane woodland, valley and foothill grassland. In roadside ditches, dry gravelly areas along roads, and along small streams. 360-440 m.		X		X		X						X						
Cobb Mountain lupine *Lupinus sericatus*	1B.2	Chaparral, cismontane woodland, lower montane coniferous forest. In stands of knobcone pine-oak woodland, on open wooded slopes in gravelly soils; sometimes on serpentine. 180-1500 m.	X	X	X	X	X		X											
Tidestrom's lupine *Lupinus tidestromii*	FE, SE, 1B.1	Coastal dunes. Includes lupinus tidestromii var. Tidestromii, state-listed endangered. Partially stabilized dunes, immediately near the ocean. 0-35 m.	X							X										
running-pine *Lycopodium clavatum*	4.1	Lower montane coniferous forest, north coast coniferous forest, marshes and swamps. Forest understory, edges, openings, roadsides; mesic sites with partial shade and light. 45-1225 m.	X	X	X												X			
Hall's bush-mallow *Malacothamnus hallii*	1B.2	Chaparral. Some populations on serpentine. 10-550 m.		X			X		X											
Mendocino bush-mallow *Malacothamnus mendocinensis*	1A	Cismontane woodland. Open, roadside banks. Label location info inconsistent with elevation info. 420-575 m?		X		X														
northern microseris *Microseris borealis*	2B.1	Bogs and fens, meadows and seeps, lower montane coniferous forest. 940-2000 m.		X	X			X									X			
marsh microseris *Microseris paludosa*	1B.2	Closed-cone coniferous forest, cismontane woodland, coastal scrub, valley and foothill grassland. 5-300 m.	X	X	X	X	X	X												
elongate copper moss *Mielichhoferia elongata*	2B.2	Cismontane woodland. Commonly called "copper mosses." Moss growing on very acidic, metamorphic rock or substrate; usually in higher portions in fens. Often on substrates naturally enriched with heavy metals (e.g., copper). 0-1300 m.	X	X		X											X			
leafy-stemmed mitrewort *Mitellastra caulescens*	4.2	Broadleafed upland forest, lower montane coniferous forest, meadows and seeps, north coast coniferous forest. Mesic sites. 5-1700 m.		X	X	X		X									X			

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northern curly-leaved monardella *Monardella sinuata* ssp. *nigrescens*	1B.2	Coastal dunes, coastal scrub, chaparral, lower montane coniferous forest. Sandy soils. 0-300 m.	X		X		X			X										
Baker's navarretia *Navarretia leucocephala* ssp. *bakeri*	1B.1	Cismontane woodland, meadows and seeps, vernal pools, valley and foothill grassland, lower montane coniferous forest. Vernal pools and swales; adobe or alkaline soils. 5-950 m.	X	X	X	X		X								X	X			
few-flowered navarretia *Navarretia leucocephala* ssp. *pauciflora*	FE, ST, 1B.1	Vernal pools. Volcanic ash flow, and volc substrate vernal pools. 400-855 m.		X												X				
many-flowered navarretia *Navarretia leucocephala* ssp. *plieantha*	FE, SE, 1B.2	Vernal pools. Volcanic ash flow vernal pools. 30-950 m.	X	X												X				
small pincushion navarretia *Navarretia myersii* ssp. *deminuta*	1B.1	Vernal pools. Known from only one site in lake county in vernal pool habitat on clay-loam soil; also in roadside depressions. 355 m.		X												X				
Marin County navarretia *Navarretia rosulata*	1B.2	Closed-cone coniferous forest, chaparral. Dry, open rocky places; can occur on serpentine. 200-635 m.	X	X	X		X		X											
Wolf's evening-primrose *Oenothera wolfii*	1B.1	Coastal bluff scrub, coastal dunes, coastal prairie, lower montane coniferous forest. Sandy substrates; usually mesic sites. 3-800 m.		X	X		X	X		X										
northern adder's-tongue *Ophioglossum pusillum*	2B.2	Marshes and swamps, meadows and seeps. Marsh edges, low pastures, grassy roadside ditches. Also described as in "open swamp." 1000-2000 m.		X				X								X				
slender Orcutt grass *Orcuttia tenuis*	FT, SE, 1B.1	Vernal pools. 30-1735 m.		X												X				
seacoast ragwort *Packera bolanderi* var. *bolanderi*	2B.2	Coastal scrub, north coast coniferous forest. 30-650 m.		X	X		X													
Geysers panicum *Panicum acuminatum* var. *thermale*	SE, 1B.2	Closed-cone coniferous forest, riparian forest, valley and foothill grassland. Usually around moist, warm soil in the vicinity of hot springs. 305-825 m.	X		X			X										X		
Sonoma beardtongue *Penstemon newberryi* var. *sonomensis*	1B.3	Chaparral. Crevices in rock outcrops and talus slopes. 180-1390 m.	X	X			X													

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white-rayed pentachaeta *Pentachaeta bellidiflora*	FE, SE, 1B.1	Valley and foothill grassland. Open dry rocky slopes and grassy areas, often on soils derived from serpentine bedrock. 35-620 m.	X					X	X											
North Coast phacelia *Phacelia insularis* var. *continentis*	1B.2	Coastal bluff scrub, coastal dunes. Open maritime bluffs, sandy soil. 10-160 m.	X	X			X			X										
Bolander's beach pine *Pinus contorta* ssp. *bolanderi*	1B.2	Closed-cone coniferous forest. Podzol-like soils with Mendocino cypress and bishop pine; within pygmy cypress forest. 35-250 m.		X	X															
white-flowered rein orchid *Piperia candida*	1B.2	North coast coniferous forest, lower montane coniferous forest, broadleafed upland forest. Coast ranges from Santa Cruz County north; on serpentine. Forest duff, mossy banks, rock outcrops and muskeg. 0-1200 m.	X	X	X	X			X											
Point Reyes rein orchid *Piperia elegans* ssp. *decurtata*	1B.1	Coastal bluff scrub. 15-185 m.	X				X													
hairless popcornflower *Plagiobothrys glaber*	1A	Meadows and seeps, marshes and swamps. Coastal salt marshes and alkaline meadows. 5-180 m.	X					X				X					X			
bearded popcornflower *Plagiobothrys hystriculus*	1B.1	Vernal pools, valley and foothill grassland. Wet sites. 10-50 m.		X				X								X				
Mayacamas popcornflower *Plagiobothrys lithocaryus*	1A	Meadows, valley and foothill grassland, cismontane woodland, chaparral, moist sites. 285-450 m.		X		X	X	X												
Petaluma popcornflower *Plagiobothrys mollis* var. *vestitus*	1A	Valley and foothill grassland, coastal salt marsh, wet sites in grassland, possibly coastal marsh margins. 10-50 m.	X					X				X								
Calistoga popcornflower *Plagiobothrys strictus*	FE, ST	Broadleafed upland forest, meadows and seeps, valley and foothill grassland, vernal pools. Alkaline sites near thermal springs and on margins of vernal pools in heavy, dark, adobe-like clay. 90-160 m.	X	X		X		X								X	X			
North Coast semaphore grass *Pleuropogon hooverianus*	ST, 1B.1	Broadleafed upland forest, meadows and seeps, north coast coniferous forest. Wet grassy, usually shady areas, sometimes freshwater marsh; associated with forest environments; 10-1150 m.	X	X	X	X		X									X			
Napa blue grass *Poa napensis*	FE, SE, 1B.1	Meadows and seeps, valley and foothill grassland. Moist alkaline meadows fed by runoff from nearby hot springs. 100-125 m.		X				X									X			

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Oregon polemonium *Polemonium carneum*	2B.2	Coastal prairie, coastal scrub, lower montane coniferous forest. 0-1830 m.	X		X		X	X												
Marin knotweed *Polygonum marinense*	3.1	Marshes and swamps. Coastal salt marshes and brackish marshes. 0-10 m.	X	X								X					X			
Nuttall's ribbon-leaved pondweed *Potamogeton epihydrus*	2B.2	Marshes and swamps. Shallow water, ponds, lakes, streams, irrigation ditches. 400-2110 m.		X										X	X		X			
eel-grass pondweed *Potamogeton zosteriformis*	2B.2	Marshes and swamps. Ponds, lakes, streams. 0-1860 m.		X										X	X		X			
Cunningham Marsh cinquefoil *Potentilla uliginosa*	1A	Freshwater marshes and swamps. Found in permanent, oligotrophic wetlands. 30-40 m.	X														X			
Pacific fuzzwort *Ptilidium californicum*	4.3	Lower montane coniferous forest, Upper montane coniferous forest. Epiphytic on fallen and decaying logs and stumps. Rarely on boulders over humus. 0-1800 m.		X	X															
dwarf alkali grass *Puccinellia pumila*	2B.2	Meadows and seeps, marshes and swamps. Mineral spring meadows and coastal salt marshes. 1-10 m.		X				X				X					X			
Tamalpais oak *Quercus parvula* var. *tamalpaisensis*	1B.3	Lower montane coniferous forest. 100-750 m.	X		X															
angel's hair lichen *Ramalina thrausta*	2B.1	North coast coniferous forest. On dead twigs and other lichens. 75-430 m.	X	X	X															
white beaked-rush *Rhynchospora alba*	2B.2	Bogs and fens, marshes and swamps. Freshwater marshes and sphagnum bogs. 60-2000 m.	X	X													X			
California beaked-rush *Rhynchospora californica*	1B.1	Bogs and fens, marshes and swamps, lower montane coniferous forest, meadows and seeps. Freshwater seeps and open marshy areas. 45-1000 m.	X	X	X			X									X			
brownish beaked-rush *Rhynchospora capitellata*	2B.2	Lower montane coniferous forest, meadows and seeps, marshes and swamps, upper montane coniferous forest. Mesic sites. 455-2000 m.	X		X												X			
round-headed beaked-rush *Rhynchospora globularis*	2B.1	Marshes and swamps. Freshwater marsh. 45-60 m.	X														X			
great burnet *Sanguisorba officinalis*	2B.2	Bogs and fens, meadows and seeps, broadleafed upland forest, marshes and swamps, north coast coniferous forest, ripar. Forest. Rocky serpentine seepage areas and along stream borders. 60-1400 m.		X	X	X		X	X								X	X		

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Lake County stonecrop *Sedella leiocarpa*	FE, SE, 1B.1	Valley and foothill grassland, vernal pools, cismontane woodland. Level areas that are seasonally wet and dry out in late spring; substrate usually of volcanic origin. 365-790 m.		X		X		X								X				
Red Mountain stonecrop *Sedum laxum* ssp. *eastwoodiae*	1B.2	Lower montane coniferous forest. Serpentine soils among rocks. 600-1200 m.		X	X				X											
Point Reyes checkerbloom *Sidalcea calycosa* ssp. *rhizomata*	1B.2	Marshes and swamps. Freshwater marshes near the coast. 3-75 m.	X	X													X			
Napa checkerbloom *Sidalcea hickmanii* ssp. *napensis*	1B.1	Chaparral. Rhyolitic substrates. 415-610 m.	X	X			X													
Lake Pillsbury checkerbloom *Sidalcea hickmanii* ssp. *pillsburiensis*	1B.2	Chaparral. Openings in chaparral on franciscan soils. 700 m.		X			X													
Marin checkerbloom *Sidalcea hickmanii* ssp. *viridis*	1B.3	Chaparral. Serpentine or volcanic soils; sometimes appears after burns. 0-430 m.	X				X		X											
Keck's checkerbloom *Sidalcea keckii*	FE, 1B.1	Cismontane woodland, valley and foothill grassland grassy slopes in blue oak woodland. 180-425 m.		X		X		X												
Siskiyou checkerbloom *Sidalcea malviflora* ssp. *patula*	1B.2	Coastal prairie, broadleafed upland forest. Open coastal forest. 15-65 m.		X		X		X												
purple-stemmed checkerbloom *Sidalcea malviflora* ssp. *purpurea*	1B.2	Broadleafed upland forest, coastal prairie. 15-65 m.	X	X		X		X												
marsh checkerbloom *Sidalcea oregana* ssp. *hydrophila*	1B.2	Meadows and seeps, riparian forest. Wet soil of streambanks, meadows. 545-2300 m.	X	X				X						X			X	X		
Kenwood Marsh checkerbloom *Sidalcea oregana* ssp. *valida*	FE, SE, 1B.1	Marshes and swamps. Edges of freshwater marshes. 115-150 m.	X														X			
Red Mountain catchfly *Silene campanulata* ssp. *campanulata*	SE, 4.2	Lower montane coniferous forest, chaparral. State-listed endangered, but CNPS list 4; eo's mostly archived. Rocky dry shallow serpentine soil. 420-1200 m. Element occurrences archived; CNPS list 4.		X	X		X		X											

Table 4-3 California Natural Diversity Database Occurrences Plant Species in Marin/Sonoma Mosquito and Vector Control District and its Adjacent Program Area

Species Name	Status	Habitat	MSMVCD	MSMVCD Adjacent Counties	Conifer Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Tree Holes	Tidal Marsh and Channels	Lagoon	Creeks and Rivers	Ponds and Lakes	Seasonal Wetlands (includes Vernal Pools)	FW Marsh/Seeps	Riparian Forest	Temporary Standing Waters and Artificial Ponds	Wastewater Treatment Facilities/Septic Systems
Santa Cruz microseris *Stebbinsoseris decipiens*	1B.2	Broadleafed upland forest, closed-cone coniferous forest, chaparral, coastal prairie, coastal scrub. Open areas in loose or disturbed soil, usu. Derived from sandstone, shale, or serp on seaward slopes. 10-500 m.	X		X	X	X	X												
Tamalpais jewelflower *Streptanthus batrachopus*	1B.3	Closed-cone coniferous forest, chaparral. Talus serpentine outcrops. 410-650 m.	X		X		X		X											
Socrates Mine jewelflower *Streptanthus brachiatus* ssp. *brachiatus*	1B.2	Chaparral, closed-cone coniferous forest. Serpentine areas and serpentine chaparral. 545-1000 m.	X	X	X		X		X											
Freed's jewelflower *Streptanthus brachiatus* ssp. *hoffmanii*	1B.2	Chaparral, cismontane woodland. Serpentine rock outcrops, primarily in geothermal development areas. 480-1030 m.	X	X		X	X		X											
Hoffman's bristly jewelflower *Streptanthus glandulosus* ssp. *hoffmanii*	1B.3	Chaparral, cismontane woodland, valley and foothill grassland. Moist, steep rocky banks, in serpentine and non-serpentine soil. 120-475 m.	X			X	X	X	X											
Tiburon jewelflower *Streptanthus glandulosus* ssp. *niger*	FE, SE, 1B.1	Valley and foothill grassland. Shallow, rocky serpentine slopes. 30-150 m.	X					X	X											
Mt. Tamalpais bristly jewelflower *Streptanthus glandulosus* ssp. *pulchellus*	1B.2	Chaparral, valley, and foothill grassland. Serpentine slopes. 150-800 m.	X				X	X	X											
green jewelflower *Streptanthus hesperidis*	1B.2	Chaparral, cismontane woodland. Openings in chaparral or woodland; serpentine, rocky sites. 130-760 m.		X		X	X		X											
Morrison's jewelflower *Streptanthus morrisonii*	1B.2	Chaparral, cismontane woodland, closed-cone coniferous forest. The complex has been mapped as the species, though at least 4 ssp. Have been recognized. On serpentine. 90-1035 m.	X	X	X	X	X		X											
early jewelflower *Streptanthus vernalis*	1B.2	Chaparral, closed-cone coniferous forest. On serpentine. 610 m.		X	X		X		X											
slender-leaved pondweed *Stuckenia filiformis* ssp. *alpina*	2B.2	Marshes and swamps. Shallow, clear water of lakes and drainage channels. 300-2150 m.	X											X	X		X			
Suisun Marsh aster *Symphyotrichum lentum*	1B.2	Marshes and swamps (brackish and freshwater). Most often seen along sloughs with phragmites, scirpus, blackberry, typha, etc. 0-3 m.		X								X					X			

Table 4-3 California Natural Diversity Database Occurrences Plant Species in Marin/Sonoma Mosquito and Vector Control District and its Adjacent Program Area

Species Name	Status	Habitat	MSMVCD	MSMVCD Adjacent Counties	Conifer Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Tree Holes	Tidal Marsh and Channels	Lagoon	Creeks and Rivers	Ponds and Lakes	Seasonal Wetlands (includes Vernal Pools)	FW Marsh/Seeps	Riparian Forest	Temporary Standing Waters and Artificial Ponds	Wastewater Treatment Facilities/Septic Systems
whiteworm lichen *Thamnolia vermicularis*	2B.1	Chaparral, valley, and foothill grassland. On rocks derived from Wilson Ranch formation sandstone.	X				X	X												
robust false lupine *Thermopsis robusta*	1B.2	North coast coniferous forest, broadleafed upland forest. Ridgetops; sometimes on serpentine. 360-1290 m.		X	X	X			X											
alpine crisp moss *Tortella alpicola*	2B.3	Cismontane woodland. Moss on volcanic rock (in California). Wide ecological tolerance: shaded or exposed, wet or dry, low to high elevations.		X		X														
beaked tracyina *Tracyina rostrata*	1B.2	Cismontane woodland, valley and foothill grassland. Open grassy meadows within oak woodland and grassland habitats. 150-500 m.	X	X		X		X												
cylindrical trichodon *Trichodon cylindricus*	2B.2	Broadleafed upland forest, upper montane coniferous forest. Moss growing in openings on sandy or clay soils on roadsides, stream banks, trails or in fields. 50-1500 m.		X	X	X														
Napa bluecurls *Trichostema ruygtii*	1B.2	Cismontane woodland, chaparral, valley, and foothill grassland, vernal pools, lower montane coniferous forest. Often in open, sunny areas. Also has been found in vernal pools. 30-590 m.		X	X	X	X	X								X				
showy rancheria clover *Trifolium amoenum*	FE, 1B.1	Valley and foothill grassland, coastal bluff scrub. Sometimes on serpentine soil, open sunny sites, swales. Most recently sited on roadside and eroding cliff face. 5-560 m.	X	X			X	X	X											
Santa Cruz clover *Trifolium buckwestiorum*	1B.1	Coastal prairie, broadleafed upland forest, cismontane woodland. Moist grassland. 60-545 m.	X	X		X		X												
saline clover *Trifolium hydrophilum*	1B.2	Marshes and swamps, valley and foothill grassland, vernal pools. Mesic, alkaline sites. 0-300 m.	X	X				X								X	X			
Monterey clover *Trifolium trichocalyx*	FE, SE, 1B.1	Closed-cone coniferous forest. Poorly drained, low nutrient soil underlain with hardpan; also openings and burned areas. 120-205 m.		X	X															
San Francisco owl's-clover *Triphysaria floribunda*	1B.2	Coastal prairie, valley, and foothill grassland. On serpentine and nonserpentine substrate (such as at pt. Reyes). 10-160 m.	X					X	X											
coastal triquetrella *Triquetrella californica*	1B.2	Coastal bluff scrub, coastal scrub valley and foothill grasslands. Grows within 30 m from the coast in coastal scrub, grasslands and in open gravels on roadsides, hillsides, rocky slopes, and fields. On gravel or thin soil over outcrops. 10-100 m.	X	X			X	X												

Table 4-3 California Natural Diversity Database Occurrences Plant Species in Marin/Sonoma Mosquito and Vector Control District and its Adjacent Program Area

Species Name	Status	Habitat	MSMVCD	MSMVCD Adjacent Counties	Conifer Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Tree Holes	Tidal Marsh and Channels	Lagoon	Creeks and Rivers	Ponds and Lakes	Seasonal Wetlands (includes Vernal Pools)	FW Marsh/Seeps	Riparian Forest	Temporary Standing Waters and Artificial Ponds	Wastewater Treatment Facilities/Septic Systems
Methuselah's beard lichen *Usnea longissima*	4.2	North coast coniferous forest, broadleafed upland forest. Grows in the "redwood zone" on a variety of trees including big leaf maple, oaks, ash, Douglas-fir, and bay. 50-1460 m in California.	X	X	X	X														
oval-leaved viburnum *Viburnum ellipticum*	2B.3	Chaparral, cismontane woodland, lower montane coniferous forest.	X	X	X	X	X													

Table 4-4 **California Natural Diversity Database Occurrences Animal Species in Marin/Sonoma Mosquito and Vector Control District and its Adjacent Program Area**

Species Name	Status	Habitat	MSMVCD	MSMVCD Adjacent Counties	Upland Habitats							Wetland Habitats										
					Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Tree Holes	Open Water (Marine/Brackish)	Tidal Flats	Tidal Marsh and channels	Lagoon	Creeks and Rivers	Ponds and Lakes	Seasonal Wetlands (includes Vernal Pools)	FW Marsh/Seeps	Riparian Forest	Artificial Containers, Temporary Standing Waters and Artificial Ponds	Wastewater Treatment Facilities/Septic Systems
Invertebrates																						
San Bruno elfin butterfly *Callophrys mossii bayensis*	FE	Valley & foothill grassland. Coastal, mountainous areas with grassy ground cover, mainly in the vicinity of San Bruno Mountain, San Mateo County. Colonies are located on steep, north-facing slopes within the fog belt. Larval host plant is Sedum spathulifolium.	X					X														
Valley elderberry longhorn beetle *Desmocerus californicus dimorphus*	FT	Riparian scrub Occurs only in the Central Valley of California, in association with blue elderberry (Sambucus mexicana). Prefers to lay eggs in elderberries 2-8 inches in diameter; some preference shown for "stressed" elderberries.		X			X													X		
Mission blue butterfly *Plebejus icarioides missionensis*	SE	Inhabits grasslands of the San Francisco peninsula. Three larval host plants: Lupinus albifrons, L. variicolor, and L. formosus, of which L. albifrons is favored.	X					X														
Lotis blue butterfly *Plebejus idas lotis*	SE	Inhabits wet meadows or poorly drained sphagnum-willow bogs, where soils are waterlogged & acidic; north coastal Calif. Inhabits upper edges of peat bog between peat & surrounding low willows; hostplant is Lotus formosissimus.		X															X			
Callippe silverspot butterfly *Speyeria callippe*	FE	Restricted to the northern coastal scrub of the San Francisco peninsula. hostplant is Viola pedunculata. Most adults found on e-facing slopes; males congregate on hilltops in search of females.		X			X															
Behren's silverspot butterfly *Speyeria zerene behrensii*	FE	Restricted to the pacific side of the coast ranges, from point arena to Cape Mendocino, Mendocino County inhabits coastal terrace prairie habitat. Foodplant is Viola sp.	X	X				X														

Table 4-4 California Natural Diversity Database Occurrences Animal Species in Marin/Sonoma Mosquito and Vector Control District and its Adjacent Program Area

Species Name	Status	Habitat	MSMVCD	MSMVCD Adjacent Counties	Upland Habitats							Wetland Habitats										
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Myrtle's silverspot *Speyeria zerene myrtleae*	FE	Restricted to the foggy, coastal dunes/hills of the point reyes peninsula; extirpated from coastal San Mateo County. Larval foodplant thought to be Viola adunca.	X				X	X		X												
California freshwater shrimp *Syncaris pacifica*	FE, SE	Endemic to Marin, Napa, and Sonoma Counties. Found in low elevation, low gradient streams where riparian cover is moderately shallow pools away from main streamflow. Winter: undercut banks with exposed roots. Summer: leafy branches touching water.	X	X												X						
Fish																						
Sacramento perch *Archoplites interruptus*	SSC	Historically found in the sloughs, slow-moving rivers, and lakes of the Central Valley. Prefers warm water. Aquatic vegetation is essential for young. Tolerates wide range of physio-chemical water conditions.		X												X	X					
Tidewater goby *Eucyclogobius newberry*	FE, SSC	Brackish water habitats along the California coast from Agua Hedionda Lagoon, San Diego County to the mouth of the Smith river. Found in shallow lagoons and lower stream reaches, they need fairly still but not stagnant water and high oxygen levels.	X	X										X	X	X						
Russian River tule perch *Hysterocarpus traski pomo*	SSC	Low elevation streams of the Russian River system. Requires clear, flowing water with abundant cover. They also require deep (> 1 m) pool habitat.	X													X						
Clear Lake hitch *Lavinia exilicauda chi*	SCT, SSC	Found only in Clear Lake, Lake County, and associated ponds. spawns in streams flowing into clear lake. Adults found in the limnetic zone. Juveniles found in the nearshore shallow-water habitat hiding in the vegetation.		X													X					
Navarro roach *Lavinia symmetricus navarroensis*	SSC	Habitat generalists. Found in warm intermittent streams as well as cold, well-aerated streams.	X	X												X						

Table 4-4 California Natural Diversity Database Occurrences Animal Species in Marin/Sonoma Mosquito and Vector Control District and its Adjacent Program Area

Species Name	Status	Habitat	MSMVCD	MSMVCD Adjacent Counties	Upland Habitats							Wetland Habitats										
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Gualala roach *Lavinia symmetricus parvipinnis*	SSC	Found only in the Gualala River.	X	X												X						
Tomales roach Lavinia symmetricus ssp. 2	SSC	Tributaries to Tomales Bay.	X													X						
Hardhead *Mylopharodon conocephalus*	SSC	Low to mid-elevation streams in the Sacramento-San Joaquin drainage. Also present in the Russian River. Clear, deep pools with sand-gravel-boulder bottoms and slow water velocity. Not found where exotic centrarchids predominate.	X		X											X						
Pink salmon *Oncorhynchus gorbuscha*	SSC	Most spawn in intertidal or lower reaches of streams and rivers in September and October move further upstream in Sacramento river. Optimal temperature is 5.6 to 14.4ºC. Embryos and alevins require fast-flowing, well oxygenated water for development and survival.		X	X											X						
Coho salmon - central California coast ESU *Oncorhynchus kisutch*	FE, SE	Federal listing = populations between Punta Gorda and San Lorenzo River. State listing = populations south of punta gorda. Require beds of loose, silt-free, coarse gravel for spawning. Also need cover, cool water, and sufficient dissolved oxygen.	X	X										X	X	X						
Steelhead - central California coast DPS *Oncorhynchus mykiss irideus*	FT	From Russian River, south to Soquel Creek and to, but not including, Pajaro River. Also San Francisco and San Pablo Bay basins.	X	X										X	X	X						
Sacramento splittail *Pogonichthys macrolepidotus*	SSC	Endemic to the lakes and rivers of the Central Valley, but now confined to the Delta, Suisun Bay & associated marshes. Slow moving river sections, dead end sloughs. Requires flooded vegetation for spawning & foraging for young.	X	X										X		X						

Table 4-4 **California Natural Diversity Database Occurrences Animal Species in Marin/Sonoma Mosquito and Vector Control District and its Adjacent Program Area**

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Longfin smelt *Spirinchus thaleichthys*	FCT, ST, SSC	Euryhaline, nektonic and anadromous. Found in open waters of estuaries, mostly in middle or bottom of water column. Prefer salinities of 15-30 ppt, but can be found in completely freshwater to almost pure seawater.	X	X								X										
Eulachon *Thaleichthys pacificus*	FT, SSC	Found in Klamath River, Mad River, Redwood Creek & in small numbers in Smith River & Humboldt Bay tributaries. Spawn in lower reaches of coastal rivers w/ moderate water velocities & bottom of pea-sized gravel, sand & woody debris.	X											X	X	X						
Amphibians																						
California Tiger Salamander *Ambystoma californiense*	FT, ST, SSC	Central Valley DPS federally listed as threatened. Santa Barbara and Sonoma Counties DPS federally listed as endangered. Need underground refuges, especially ground squirrel burrows and vernal pools or other seasonal water sources for breeding	X					X										X				
Pacific tailed frog *Ascaphus truei*	SSC	Occurs in montane hardwood-conifer, redwood, Douglas-fir and ponderosa pine habitats. Restricted to perennial montane streams. Tadpoles require water below 15 degrees C.		X												X						
Northern red-legged frog *Rana aurora*	SSC	Humid forests, woodlands, grasslands, and streamsides in northwestern California, usually near dense riparian cover. Generally near permanent water, but can be found far from water, in damp woods and meadows, during nonbreeding season.		X	X	X		X								X	X		X	X		
Foothill yellow-legged frog *Rana boylii*	SSC	Partly shaded, shallow streams and riffles with a rocky substrate in a variety of habitats. Need at least some cobble-sized substrate for egg-laying. Need at least 15 weeks to attain metamorphosis.	X	X	X											X				X		

Table 4-4 **California Natural Diversity Database Occurrences Animal Species in Marin/Sonoma Mosquito and Vector Control District and its Adjacent Program Area**

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California red-legged frog *Rana draytonii*	FT, SSC	Lowlands and foothills in or near permanent sources of deep water with dense, shrubby or emergent riparian vegetation. Requires 11-20 weeks of permanent water for larval development. Must have access to estivation habitat.	X	X												X	X		X	X		
Southern torrent salamander *Rhyacotriton variegatus*	SSC	Coastal redwood, Douglas-fir, mixed conifer, montane riparian, and montane hardwood-conifer habitats. old growth forest. Cold, well-shaded, permanent streams and seepages, or within splash zone or on moss-covered rock within trickling water.		X	X	X											X					
Reptiles																						
Western pond turtle *Emys marmorata*	SSC	A thoroughly aquatic turtle of ponds, marshes, rivers, streams and irrigation ditches, usually with aquatic vegetation, be need basking sites and suitable (sandy banks or grassy open fields) upland habitat up to 0.5 km from water for egg-laying.	X	X			X	X								X	X		X	X		
Birds																						
Northern goshawk *Accipiter gentilis*	SSC	Within, and in vicinity of, coniferous forest. Uses old nests, and maintains alternate sites. Usually nests on north slopes, near water. Red fir, lodgepole pine, Jeffrey pine, and aspens are typical nest trees.		X	X															X		
Tricolored blackbird *Agelaius tricolor*	SSC	Highly colonial species, most numerous in Central Valley and vicinity. Largely endemic to California. Requires open water, protected nesting substrate, and foraging area with insect prey within a few km of the colony.	X	X										X					X	X		

Table 4-4 **California Natural Diversity Database Occurrences Animal Species in Marin/Sonoma Mosquito and Vector Control District and its Adjacent Program Area**

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Grasshopper sparrow *Ammodramus savannarum*	SSC	Dense grasslands on rolling hills, lowland plains, in valleys and on hillsides on lower mountain slopes. Favors native grasslands with a mix of grasses, forbs and scattered shrubs. Loosely colonial when nesting.		X				X														
Golden eagle *Aquila chrysaetos*	FP	Rolling foothills, mountain areas, sage-juniper flats, and desert. Cliff-walled canyons provide nesting habitat in most parts of range; also, large trees in open areas.		X			X	X														
Burrowing owl *Athene cunicularia*	SSC	Open, dry annual or perennial grasslands, deserts and scrublands characterized by low-growing vegetation. Subterranean nester, dependent upon burrowing mammals, most notably, the California ground squirrel.	X	X			X	X														
Swainson's hawk *Buteo swainsoni*	SSC	Breeds in grasslands with scattered trees, juniper-sage flats, riparian areas, savannahs, and agricultural or ranch lands requires adjacent suitable foraging areas such as grasslands, or alfalfa or grain fields supporting rodent populations.	X	X			X	X												X		
Western snowy plover *Charadrius alexandrinus nivosus*	FT, SSC	Sandy beaches, salt pond levees and shores of large alkali lakes. Needs sandy, gravelly or friable soils for nesting.	X	X						X												
Northern harrier *Circus cyaneus*	SSC	Coastal salt and fresh-water marsh. nest and forage in grasslands, from salt grass in desert sink to mountain cienagas. Nests on ground in shrubby vegetation, usually at marsh edge; nest built of a large mound of sticks in wet areas.	X	X				X						X					X			

Table 4-4 **California Natural Diversity Database Occurrences Animal Species in Marin/Sonoma Mosquito and Vector Control District and its Adjacent Program Area**

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Western yellow-billed cuckoo *Coccyzus americanus occidentalis*	SE, FP	Riparian forest nester, along the broad, lower flood-bottoms of larger river systems. Nests in riparian jungles of willow, often mixed with cottonwoods, with lower story of blackberry, nettles, or wild grape.	X	X																X		
Black swift *Cypseloides niger*	SSC	Coastal belt of Santa Cruz and Monterey County; central and southern Sierra Nevada; San Bernardino and San Jacinto Mountains. Breeds in small colonies on cliffs behind or adjacent to waterfalls in deep canyons and sea-bluffs above the surf; forages widely.	X	X						X										X		
White-tailed kite *Elanus leucurus*	FP	Rolling foothills and valley margins with scattered oaks and river bottomlands or marshes next to deciduous woodland. Open grasslands, meadows, or marshes for foraging close to isolated, dense-topped trees for nesting and perching.	X	X		X		X											X	X		
American peregrine falcon *Falco peregrinus anatum*	FP	Near wetlands, lakes, rivers, or other water; on cliffs, banks, dunes, mounds; also, human-made structures. Nest consists of a scrape or a depression or ledge in an open site.	X	X										X	X	X	X		X			
Bald eagle *Haliaeetus leucocephalus*	FD, SE, FP,	Ocean shore, lake margins, and rivers for both nesting and wintering. Most nests within 1 mile of water. Nests in large, old-growth, or dominant live tree with open branches, especially ponderosa pine. Roosts communally in winter.		X												X	X					
Saltmarsh common yellowthroat *Geothlypis trichas sinuosa*	SSC	Resident of the San Francisco Bay region, in fresh and salt water marshes. Requires thick, continuous cover down to water surface for foraging; tall grasses, tule patches, willows for nesting.	X	X										X					X			

Table 4-4 California Natural Diversity Database Occurrences Animal Species in Marin/Sonoma Mosquito and Vector Control District and its Adjacent Program Area

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Yellow-breasted chat *Icteria virens*	SSC	Summer resident; inhabits riparian thickets of willow and other brushy tangles near watercourses. Nests in low, dense riparian, consisting of willow, blackberry, wild grape; forages and nests within 10 ft of ground.		X																X		
California black rail *Laterallus jamaicensis coturniculus*	ST	Inhabits freshwater marshes, wet meadows and shallow margins of saltwater marshes bordering larger bays. Needs water depths of about 1 inch that does not fluctuate during the year and dense vegetation for nesting habitat.	X	X				X						X					X			
Song sparrow ("Modesto" population) *Melospiza melodia*	SSC	Emergent freshwater marshes dominated by tules (Scirpus spp.) and cattails (Typha spp.) as well as riparian willow (Salix spp.) thickets. Primary habitat requirements include moderately dense vegetation to supply cover for nest sites, a source of standing or running water, semiopen canopies to allow light, and exposed ground or leaf litter for foraging.	X	X															X	X		
San Pablo song sparrow *Melospiza melodia samuelis*	SSC	Resident of salt marshes along the north side of San Francisco and San Pablo Bays. Inhabits tidal sloughs in the salicornia marshes; nests in grindelia bordering slough channels.	X	X										X								
Purple martin *Progne subis*	SSC	Inhabits woodlands, low elevation coniferous forest of Douglas-fir, ponderosa pine, and Monterey pine. Nests in old woodpecker cavities mostly, also in human-made structures. Nest often located in tall, isolated tree/snag.	X	X	X						X											

Table 4-4 **California Natural Diversity Database Occurrences Animal Species in Marin/Sonoma Mosquito and Vector Control District and its Adjacent Program Area**

Species Name	Status	Habitat	MSMVCD	MSMVCD Adjacent Counties	Upland Habitats							Wetland Habitats										
					Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Tree Holes	Open Water (Marine/Brackish)	Tidal Flats	Tidal Marsh and channels	Lagoon	Creeks and Rivers	Ponds and Lakes	Seasonal Wetlands (includes Vernal Pools)	FW Marsh/Seeps	Riparian Forest	Artificial Containers, Temporary Standing Waters and Artificial Ponds	Wastewater Treatment Facilities/Septic Systems
California clapper rail *Rallus longirostris obsoletus*	FE, SE, FP	Salt-water and brackish marshes traversed by tidal sloughs in the vicinity of San Francisco Bay. Associated with abundant growths of pickleweed, but feeds away from cover on invertebrates from mud-bottomed sloughs.	X	X										X								
Bank swallow *Riparia riparia*	ST	Colonial nester; nests primarily in riparian and other lowland habitats west of the desert. Requires vertical banks/cliffs with fine-textured/sandy soils near streams, rivers, lakes, ocean to dig nesting hole.	X	X																X		
Yellow warbler *Setophaga petechia*	SSC	Riparian plant associations in close proximity to water. Also nests in montane shrubbery in open conifer forests in Cascades and Sierra Nevada. Frequently found nesting and foraging in willow shrubs and thickets, and in other riparian plants including cottonwoods, sycamores, ash, and alders.	X	X	X															X		
Mammals																						
Pallid bat *Antrozous pallidus*	SSC	Deserts, grasslands, shrublands, woodlands and forests. Most common in open, dry habitats with rocky areas for roosting. Roosts must protect bats from high temperatures. Very sensitive to disturbance of roosting sites.	X	X	X	X	X	X														
Point Arena mountain beaver *Aplodontia rufa nigra*	FE, SSC	Coastal areas of Point Arena with springs or seepages. North-facing slopes of ridges and gullies with friable soils and thickets of undergrowth.		X															X			
Point Reyes mountain beaver *Aplodontia rufa phaea*	SSC	Coastal area of Point Reyes in areas of springs or seepages. North-facing slopes of hills and gullies in areas overgrown with sword ferns and thimbleberries.	X																X			

Table 4-4 California Natural Diversity Database Occurrences Animal Species in Marin/Sonoma Mosquito and Vector Control District and its Adjacent Program Area

Species Name	Status	Habitat	MSMVCD	MSMVCD Adjacent Counties	Upland Habitats							Wetland Habitats										
					Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Tree Holes	Open Water (Marine/Brackish)	Tidal Flats	Tidal Marsh and channels	Lagoon	Creeks and Rivers	Ponds and Lakes	Seasonal Wetlands (includes Vernal Pools)	FW Marsh/Seeps	Riparian Forest	Artificial Containers, Temporary Standing Waters and Artificial Ponds	Wastewater Treatment Facilities/Septic Systems
Sonoma tree vole *Arborimus pomo*	SSC	North coast fog belt from Oregon border to Sonoma County in Douglas-fir, redwood and montane hardwood-conifer forests. Feeds almost exclusively on Douglas-fir needles. Will occasionally take needles of grand fir, hemlock or spruce.	X	X	X																	
Townsend's big-eared bat *Corynorhinus townsendii*	SC, SSC	Throughout California in a wide variety of habitats. Most common in mesic sites. Roosts in the open, hanging from walls and ceilings. Roosting sites limiting. Extremely sensitive to human disturbance.	X	X		X	X	X														
California wolverine *Gulo gulo*	ST, FP	Found in the north coast mountains and the Sierra Nevada. Found in a wide variety of high elevation habitats. Needs water source. Uses caves, logs, burrows for cover and den area. Hunts in more open areas. can travel long distances		X	X																	
Western red bat *Lasiurus blossevillii*	SSC	Roosts primarily in trees, 2-40 ft above ground, from sea level up through mixed conifer forests. Prefers habitat edges and mosaics with trees that are protected from above and open below with open areas for foraging.	X	X	X		X	X														
Humboldt marten *Martes americana humboldtensis*	SSC	Occurs only in the coastal redwood zone from the Oregon border south to Sonoma County. Associated with late-successional coniferous forests, prefer forests with low, overhead cover.		X	X																	
Fisher - West Coast DPS *Pekania pennanti*	FC, SC, SSC	Intermediate to large-tree stages of coniferous forests & deciduous-riparian areas with high percent canopy closure. Uses cavities, snags, logs and rocky areas for cover & denning. Needs large areas of mature, dense forest.	X	X	*X*															X		

Table 4-4 California Natural Diversity Database Occurrences Animal Species in Marin/Sonoma Mosquito and Vector Control District and its Adjacent Program Area

Species Name	Status	Habitat	MSMVCD	MSMVCD Adjacent Counties	Upland Habitats							Wetland Habitats										
					Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Tree Holes	Open Water (Marine/Brackish)	Tidal Flats	Tidal Marsh and channels	Lagoon	Creeks and Rivers	Ponds and Lakes	Seasonal Wetlands (includes Vernal Pools)	FW Marsh/Seeps	Riparian Forest	Artificial Containers, Temporary Standing Waters and Artificial Ponds	Wastewater Treatment Facilities/Septic Systems
Salt-marsh harvest mouse *Reithrodontomys raviventris*	FE, SE, FP	Only in the saline emergent wetlands of San Francisco Bay and its tributaries. Pickleweed is primary habitat. Do not burrow, build loosely organized nests. Require higher areas for flood escape.	X	X										X								
Suisun shrew *Sorex ornatus sinuosus*	SSC	Tidal marshes of the northern shores of San Pablo and Suisun Bays. Require dense low-lying cover and driftweed and other litter above the mean hightide line for nesting and foraging.	X	X										X								
American badger *Taxidea taxus*	SSC	Most abundant in drier open stages of most shrub, forest, and herbaceous habitats, with friable soils. Needs sufficient food, friable soils and open, uncultivated ground. Preys on burrowing rodents. Digs burrows.	X	X		X	X	X														
Point Reyes jumping mouse *Zapus trinotatus orarius*	SSC	Primarily in bunch grass marshes on the uplands of Point Reyes. Also present in coastal scrub, grassland, and meadows. Eats mainly grass seeds with some insects and fruit taken. Builds grassy nests on ground under vegetation, burrows in winter	X				X	X											X			

FE = federally listed as endangered
FT = federally listed as threatened
FC = federal candidate species
SE = listed by California as endangered
ST = listed by California as threatened
SSC = California species of concern
FP = California Fully Protected species

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4.1.3 Regulatory Setting

The regulatory setting includes the federal, state, and local laws, statutes, and regulations pertinent to the Program Area and vicinity and the aquatic resources residing therein. These laws include the following:

4.1.3.1 Federal

4.1.3.1.1 Endangered Species Act of 1973 (16 USC Section 1531 et seq.; 50 CFR Parts 17 and 222)

This law includes provisions for protection and management of species that are federally listed as threatened or endangered and designated critical habitat for these species. This law prohibits "take" of federally listed species, except as authorized under an incidental take permit or incidental take statement. The term "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct (http://www.fws.gov/endangered/laws-policies/section-3.html). The United States Fish and Wildlife Service (USFWS) is the administering agency for this authority for freshwater species. The National Marine Fisheries Service (NMFS) is the administering agency for anadromous species.

4.1.3.1.2 Magnusson-Stevenson Fishery Conservation and Management Act 1996 (Public Law 94-265)

This law provides for the conservation and management of all fish resources within the exclusive economic zone of the US and supports and encourages the implementation and enforcement of international fisheries agreements for conservation and management of highly migratory species. It calls for the establishment of Regional Fisheries Management Councils to develop, implement, monitor, and revise fish management plans to promote domestic commercial and recreational fishing. Specifically to this Program, it calls for the protection of essential fish habitat in review of projects conducted under federal permits, licenses, or other authorities that affect or have the potential to affect such habitat. The NMFS is responsible for the administration of this act.

4.1.3.1.3 Clean Water Act of 1977 [33 USC Section(s) 1251-1376; 30 CFR Section(s) 330.5 (a)(26)]

These sections provide for the protection of wetlands. The administering agency for the above authority is the United States Army Corps of Engineers (USACE). Under CWA Sections 301 and 502, any discharge of dredged or fill materials into "waters of the United States," including wetlands, is forbidden unless authorized by a permit issued by the USACE pursuant to Section 404. These permits are an essential part of protecting streams and wetlands. Wetlands are vital to the ecosystem in filtering streams and rivers and providing habitat for wildlife.

The USEPA is the federal agency responsible for water quality management and administers the federal Water Pollution Control Act Amendments of 1972 and 1987, collectively known as the Clean Water Act (CWA). The CWA establishes the principal federal statutes for water quality protection. It was established with the intent "to restore and maintain the chemical, physical, and biological integrity of the nation's water, to achieve a level of water quality which provides for recreation in and on the water, and for the propagation of fish and wildlife." Also see Section 9.1.2.1 in Chapter 9, Water Resources.

4.1.3.1.4 Executive Order 11990, Protection of Wetlands (May 24, 1977)

This order provides for the protection of wetlands. The administering agency for the above authority is the USACE.

4.1.3.1.5 Federal Insecticide, Fungicide, and Rodenticide Act

FIFRA defines a pesticide as “any substance intended for preventing, destroying, repelling, or mitigating any pest.” FIFRA requires USEPA registration of pesticides prior to their distribution for use in the US, sets registration criteria (testing guidelines), and mandates that pesticides perform their intended functions without causing unreasonable adverse effects on people and the environment when used according to USEPA-approved label directions. FIFRA defines an "unreasonable adverse effect on the environment" as "(1) any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of the pesticide, or (2) a human dietary risk from residues that result from a use of a pesticide in or on any food inconsistent with the standard under Section 408 of the Federal Food, Drug, and Cosmetic Act (21 USC 346a)."

FIFRA regulates only the active ingredients of pesticides, not inert ingredients, which manufacturers are not required to reveal. However, toxicity studies conducted under FIFRA are required to evaluate the active ingredient and the entire product formulation, through which any potential additive or synergistic effects of inert ingredients are established.

4.1.3.1.6 Stipulated Injunction and Order, Protection of California Red-Legged Frog from Pesticides

On October 20, 2006, the US District Court for the Northern District of California imposed no-use buffer zones around California red-legged frog upland and aquatic habitats for certain pesticides. This injunction and order will remain in effect for each pesticide listed in the injunction until the USEPA goes through formal 7(A)(2) consultation with the USFWS on each of the 66 active ingredients, and the USFWS issues a Biological Opinion including a “not likely to adversely affect” statement for the pesticides. Under the injunction and order, no-use buffer zones of 60 feet for ground applications and 200 feet for aerial applications apply from the edge of the following California red-legged frog habitats as defined by the USFWS and the Center for Biological Diversity: Aquatic Feature, Aquatic Breeding Habitat, Nonbreeding Aquatic Habitat, and Upland Habitat. These habitats are found in 33 counties of California including Marin and Sonoma counties.

Of the 66 pesticides listed in the injunction, the District may employ esfenvalerate, methoprene, and permethrin for vector control. Esfenvalerate may be used for yellow-jacket and wasp control in response to public complaints. Methoprene is used for larval mosquito control, and permethrin is may be used for adult mosquito control. However, vector control programs are exempt. Specifically, for applications of a pesticide for purposes of public health vector control under a program administered by a public entity, the injunction does not apply. The District may use the following herbicides listed in the injunction: glyphosate, imazapyr, and triclopyr. Where used for vegetation management for control of mosquito-breeding habitat, the injunction would not apply. If these herbicides were to be used for invasive species management to assist other agencies or landowners, then the injunction generally applies until such time that the material has been reviewed by USEPA and USFWS determines that it does not apply or the following “exceptions for invasive species and noxious weed programs” can be met:

a. You are applying a pesticide for purposes of controlling state-designated invasive species and noxious weeds under a program administered by a public entity; and

b. You do not apply the pesticide within 15 feet of aquatic breeding critical habitat or nonbreeding aquatic critical habitat within critical habitat areas, or within 15 feet of aquatic features within noncritical habitat sections subject to the injunction; and

c. Application is limited to localized spot treatment using hand-held devices; and

d. Precipitation is not occurring or forecast to occur within 24 hours; and

e. You are a certified applicator or working under the direct supervision of a certified applicator; and

f. If using 2,4-D or triclopyr, you are using only the amine formulations. (USEPA 2014a).

4.1.3.2 State

4.1.3.2.1 Porter-Cologne Water Quality Control Act of 1970

This law provides the California State Water Resources Control Board (SWRCB) and the nine Regional Water Quality Control Boards (RWQCBs) with authority to establish Water Quality Control Plans (Basin Plans) that are reviewed and revised periodically. The SWRCB and the RWQCBs carry out the federal Clean Water Act, including the National Pollutant Discharge Elimination System (NPDES) permitting process for point source discharges and the CWA Section 303 water quality standards program. The administering agencies are the SWRCB and the RWQCBs.

4.1.3.2.2 California Fish and Wildlife Code Section 1600 et seq.

This law provides for protection and conservation of fish and wildlife resources with respect to any project that may substantially divert or obstruct the natural flow of, or substantially change or use any material from the bed, channel, or bank of any river, stream, or lake. The administering agency is the California Department of Fish and Wildlife (CDFW).

4.1.3.2.3 California Endangered Species Act of 1984 (California Fish and Wildlife Code Sections 2050 2098)

This law provides for the protection and management of species and subspecies listed by the State of California as endangered or threatened, or designated as candidates for such listing. They are listed at 14 California Code of Regulations (CCR) Section 670.5. This law prohibits "take" of state-listed or candidate species, except as otherwise authorized by the Fish and Wildlife Code. The term "take" is defined by Section 86 of the Fish and Wildlife Code as "hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill." This definition is different in some respects from the definition of "take" under the federal Endangered Species Act. The administering agency is the CDFW.

4.1.3.2.4 California Fish and Wildlife Code §3503

This law prohibits take, possession, or needless destruction of any bird egg or nest, except as otherwise provided by the Fish and Wildlife Code or regulation made pursuant thereto. The administering agency is the CDFW.

4.1.3.2.5 California Fish and Wildlife Code §3503.5

This law prohibits take, possession, or destruction of any bird of prey (birds in the order of Falconiformes or Strigiformes), except as otherwise provided by the Fish and Wildlife Code or regulation adopted pursuant thereto. The administering agency is the CDFW.

4.1.3.2.6 California Fish and Wildlife Code §3511, 4700, and 5050

These laws prohibit take or possession of birds, mammals, and reptiles listed as "fully protected," except as provided by the Fish and Wildlife Code. The administering agency is the CDFW.

4.1.3.2.7 California Fish and Wildlife Code Section 5650

This law protects water quality from substances or materials deleterious to fish, plant life, or bird life. It prohibits such substances or materials from being placed in waters or places where they can pass into waters of the state, except as authorized pursuant to, and in compliance with, the terms and conditions of permits or authorizations of the SWRCB or a RWQCB such as a waste discharge requirement issued pursuant to California Water Code Section 13263, a waiver issued pursuant to Water Code Section 13269(a), or permit pursuant to Water Code Section 13160. The administering agency for Fish and Wildlife Code Section 5650 is the CDFW.

4.1.3.2.8 Native Plant Protection Act (California Fish and Wildlife Code §1900 et seq.)

This law provides for the preservation, protection, and enhancement of endangered or rare native plants of the state. The Native Plant Protection Act allows for the designation of endangered and rare native plant species and states that no person shall take any native plant, or any part or product thereof that the commission has determined to be an endangered native plant or rare native plant, except as otherwise provided in the act. The administering agency is the CDFW.

4.1.3.2.9 Natural Community Conservation Planning Act (California Fish and Wildlife Code §2800 to 2835)

This law provides for the development of Natural Community Conservation Plans (NCCPs) to provide for regional or areawide protection and perpetuation of natural wildlife diversity, while allowing compatible and appropriate development and growth. The administering agency is the CDFW.

4.1.3.2.10 California Food and Agricultural Code, Section(s) 12976 and Section(s) 12981

This code states that no pesticide application should be made or continued when a reasonable possibility exists of damage to nontarget crops, animals, or other public or private property. The administering agency for the above authority is the California Department of Pesticide Regulation (CDPR).

4.1.3.3 Local

Local governing bodies may pass ordinances that regulate or restrict pesticide use within their jurisdictional areas. However, these restrictions do not apply to state operations and would not be applicable to treatments proposed by the District under the Program (including those conducted under the authority of the state, specifically CDPH for the District's vector control activities) because California state law preempts local regulation and restriction of pesticide use. See Sections 1.3.3 and 3.1.3.3 for a discussion of this issue. However, a school district board can decree that certain pesticides cannot be used in schools under the Healthy Schools Act. The District works collaboratively with schools and school district administration to minimize mosquito and vector production and control populations, when necessary. The District will work with the local entities and property owners to implement best management practices for the protection of public health.

Concerning local ordinances and policies to protect biological resources, Marin County and its cities (Belvedere, Corte Madera, Fairfax, Larkspur, Mill Valley, Novato, Ross, San Anselmo, San Rafael, Sausalito, and Tiburon) and Sonoma County and its cities (Cloverdale, Cotati, Healdsburg, Petaluma, Rohnert Park, Santa Rosa, Sebastopol, Sonoma, and Windsor) maintain general plans for development and protection of lands within their jurisdictions. The general plans address the protection and enhancement of natural resources including plant, wildlife and fish habitat and special-status species with broad goals and more specific policies to implement those goals. The discussions below for Marin and Sonoma counties are examples of the local policies affecting biological resources.

4.1.3.3.1 County of Marin General Plan

The County of Marin's General Plan (Countywide Plan), adopted in 2007 (Marin County 2007), includes a Natural Systems and Agriculture Element that establishes county policies "to preserve native habitat and protect natural resources, and sets out programs to restore and enhance ailing habitat." The element describes goals relating to biological resources, water resources, environmental hazards, atmosphere and climate, open space, trails, and agriculture and food. For each of these goals policies and implementing programs are outlined. The goals most pertinent to the District's vector control activities are listed below.

> Section 2.4 Biological Resources:

- BIO-1. Enhanced Native Habitat and Biodiversity. Effectively manage and enhance native habitat, maintain viable native plant and animal populations, and provide for improved biodiversity throughout the County.
- BIO-2. Protection of Sensitive Biological Resources. Require identification of sensitive biological resources and commitment to adequate protection and mitigation, and monitor development trends and resource preservation efforts.
- BIO-3. Wetland Conservation. Require all feasible measures to avoid and minimize potential adverse impacts on existing wetlands and to encourage programs for restoration and enhancement of degraded wetlands.
- BIO-4. Riparian Conservation. Protect and, where possible, restore the natural structure and function of riparian systems.
- BIO-5. Baylands Conservation. Preserve and enhance the diversity of the baylands ecosystem, including tidal marshes and adjacent uplands, seasonal marshes and wetlands, rocky shorelines, lagoons, agricultural lands, and low-lying grasslands overlying historical marshlands.

> Section 2.5 Water Resources.

- WR-2. Clean Water. Ensure that surface and groundwater supplies are sufficiently unpolluted to support local natural communities, the health of the human population, and the viability of agriculture and other commercial uses.

> Section 2.5 Open Space.

- OS-1. Sustainably Managed Open Space. Manage open space in a sustainable manner for environmental health and the long-term protection of resources.
- This goal includes Implementing Program OS-1.C. Utilize Integrated Pest Management. Minimize the use of pesticides and herbicides in open space management. This Program is described below.

Integrated Pest Management Program

The Marin County Board of Supervisors adopted an Integrated Pest Management Ordinance (No. 3521) and IPM policy that governs and guides the control of pests on property owned, managed, and leased by the County of Marin. The IPM program uses best practices and science to protect the health of the public and environment, manage county properties, minimize loss due to pests, and reduce pesticide use. The county's IPM is overseen by an IPM Commission (Marin County Parks 2010). The IPM Policy outlines the programs purpose and intent, describes its components, and identifies the duties and responsibilities of those implementing the plan (County of Marin 2013).

4.1.3.3.2 County of Sonoma General Plan

The Sonoma County General Plan 2020 (Sonoma County 2008) was approved by the Sonoma County Board of Supervisors on September 23, 2008. This plan provides goals, objectives, and policies that will guide decisions on future growth, development, and conservation of resources through 2020 in a manner consistent with the goals and quality of life desired by the county's residents. The Plan includes the following elements pertinent to the District's activities: Open Space and Resource Conservation and Water Resources.

The Open Spaces and Resources Conservation Element includes policies addressing the protection of biotic habitats and riparian corridors. It also addresses air quality and energy resources, mineral and timber resources, and soil resources.

> OSRC-7. Protect and enhance the County's natural habitats (special-status species habitat, marshes and wetlands, sensitive natural communities, and habitat connectivity corridors) and diverse plant and animal communities.

> OSRC-8. Protect and enhance Riparian Corridors and functions along streams, balancing the need for agricultural production, urban development, timber and mining operations, and other land uses with the preservation of riparian vegetation, protection of water resources, flood control, bank stabilization, and other riparian functions and values.

> OSRC-9. Protect and conserve the quality of ocean, marine and estuarine environments for their scenic, economic, and environmental values.

The Water Resources Element recognizes the importance of natural vegetation and wildlife habitat, both as beneficial water uses whose needs must be considered but also as factors in maintaining adequate water quality and quantity.

> Goal WR-1. Protect, restore, and enhance the quality of surface and groundwater resources to meet the needs of all reasonable beneficial uses.

4.1.4 Habitat Conservation Plans and Natural Community Conservation Plans

HCPs are planning documents required as part of an application by a nonfederal entity for incidental take of a species listed under the federal Endangered Species Act as part of their proposed activities. An HCP describes the proposed action(s), and its anticipated effects on the individuals and populations of listed species. It also will describe how impacts will be minimized and mitigated. An HCP also can include protections for species that are candidates for listing or are proposed for listing. The HCP is reviewed by USFWS or National Oceanic and Atmospheric Administration (NOAA) Fisheries, when reviewing a project. If a project is approved by the USFWS or NOAA Fisheries, they will issue an incidental take permit for the project actions, which provides for take of these species based on the actions provided for in the HCP, as well as additional measures that the USFWS or NOAA Fisheries might include.

The California Natural Community Conservation Planning Act was first passed by the state legislature in 1991, and was updated and superseded in 2003. The primary objective of the NCCP program is to conserve natural communities at the ecosystem level, while accommodating compatible land use. It focuses on the long-term stability of wildlife and habitat, and seeks to avoid controversy and delays associated with species listings.

CEQA requires that an EIR consider whether a project would conflict with the provisions of an adopted HCP, NCCP, or other approved local, regional, or state habitat conservation plan. Listings of these documents on the USFWS and CDFW websites were reviewed, and four approved plans were identified, along with three plans that are currently in development (Table 4-5). In addition, one regional plan, the Santa Rosa Plain Conservation Strategy (SRPCS) is also under preparation. Two of these conservation strategies, Turkey Road and SRPCS, lie within the District's immediate Service Area. The remainder covers portions of the adjoining counties (Mendocino, Lake, Napa, and Solano). These plans are described below.

4.1.4.1 Turkey Road Low Effects HCP

This HCP was prepared by Wildlife Research Associates on behalf of Bradley Jacobs to address the effects of development of a residential property and vineyard on California red-legged frog. The HCP provides measures to minimize and mitigate the adverse effects of the project relating to 0.25 acre of permanent impacts associated with structures and roads, along with temporary disturbance of grasslands during construction, and the development of a 4.5-acre vineyard. Project impacts will be offset through purchase of 0.75 acre of habitat credits in a USFWS-approved mitigation bank.

Table 4-5 Habitat Conservation Plans and Natural Community Conservation Plans in the Marin/Sonoma Mosquito and Vector Control District Program Area

Plan Title	Location	Covered Species Listed and Nonlisted	Date Permit Issued	Size	Duration
Turkey Road Low-effects HCP	Sonoma	California red-legged frog	4/4/2014	8.5 acres	5 years
California Department of Corrections Statewide Electrified Fence Project	26 sites throughout California	45 species	6/12/2002	2,937 acres	50 years[1]
Shiloh III	Montezuma Hills Wind Resources Area, 3 miles west of Rio Vista and south of Highway 12, Solano County, CA	Salamander, California tiger (USA Central CA DPS)	5/18/2011	4,600 acres	36 years[1]
Shiloh IV	Montezuma Hills Wind Resource Area in Solano County, CA	Salamander, California tiger (USA Central CA DPS)	4/10/2012	0 acre	36 years[1]
Bay Delta Conservation Plan	Overlaps portions of 5 counties	56 Species	In Development	947,075	5 years
Solano Habitat Conservation Plan	Solano County, CA	36 Species	In Development	585,000	30 years[3] (proposed)
Mendocino Redwoods Company	Mendocino, CA	42 Species	In Development	213,000 in Mendocino County	80 years (proposed)
Santa Rosa Plains Conservation Strategy	Sonoma, CA	Salamander, California tiger (USA Central CA DPS), Burke's goldfield, Sonoma sunshine; Sebastopol meadowfoam; many-flowered navarretia	Case by case permits via a programmatic BO issued by USFWS in 2007	~43,000	Not reported

Sources:

[1] USFWS ECOS website accessed April 10, 2013: http://ecos.fws.gov/conserv_plans/PlanReport?region=8&type=HCP&rtype=2&hcpUser=&view=report
[2] CDFW NCCP website accessed April 10, 2013: http://www.dfg.ca.gov/habcon/nccp/status/NCCP Summary Table.pdf
[3] Sacramento USFWS Office website accessed October 24, 2014: http://www.fws.gov/sacramento/es/Habitat-Conservation-Plans/es_hcp.htm
The District will review these websites periodically to determine if new HCP/NCCPs are being considered for or have been implemented in their area.

Notes:

DPS = Distinct Population Segment

LE = low effect

4.1.4.2 California Department of Corrections Statewide Electrified Fence Project

This HCP was prepared by the California Department of Corrections for their Statewide Electrified Fence Project and addresses mortality or the potential for mortality of special-status species and native migratory birds at 25 prisons where lethal electrified fences are operational and 4 future sites where electrified fences are planned. The HCP provides for take of 62 species covered by the federal Endangered Species Act, California Endangered Species Act, or listed as California Species of Concern, along with an additional 57 species covered under the Migratory Bird Treaty Act, but not included in the preceding category. This HCP would apply to the Solano State Prison within the District's Adjacent Project Area, although this facility is located in Vacaville, where the District would not be expected to conduct its activities. As the HCP is confined to the prison sites and specifically to mortality due to electrocution of covered species on those fences, this HCP does not apply to the District's activities.

4.1.4.3 Shiloh III

This HCP was prepared by enXco, Inc. to cover the potential impacts of construction of the Shiloh III Wind Project, near Rio Vista, CA. The HCP addresses impacts to the central California (Distinct Population Segment (DPS) of California tiger salamander over an area of 4,600 acres for a period of 36 years. The activities covered under the HCP are the construction and installation of wind turbines and associated facilities, maintenance of these facilities, and decommissioning of these facilities in the future. These activities are anticipated to cause both permanent and temporary loss of California tiger salamander habitat. Avoidance and minimization measures (AMMs) include minimizing impact area; avoiding injury to salamanders during implementation; avoiding erosion and sedimentation impacts to habitat; avoidance of toxic spills; restoration of temporarily disturbed habitat; and ensuring AMMs are implemented. Mitigation is to offset unavoidable permanent impacts at an approved conservation bank. As this HCP is located near Rio Vista, more than 20 miles from the Napa County line, it is unlikely that the District's activities would occur within the boundaries of this HCP.

4.1.4.4 Shiloh IV

This HCP was prepared by Shiloh IV Wind Project, LLC to cover the potential impacts of construction of the Shiloh IV Wind Project, near Rio Vista, California. The project covers impacts to the central California DPS of California tiger salamander over an area of 3,514 acres for a period of 36 years. The activities covered under the HCP are installation and operations of maintenance yards, a substation, wind turbines, and associated facilities (including access roads) and decommissioning of these facilities in the future. These activities are anticipated to result in both permanent and temporary loss of California tiger salamander habitat. AMMs include minimizing impact area; avoiding injury to salamanders during implementation; avoiding erosion and sedimentation impacts to habitat; avoiding toxic spills; restoration of temporarily disturbed habitat; and ensuring AMMs are implemented. Mitigation is to offset unavoidable permanent impacts at an approved conservation bank. As this HCP is located near Rio Vista, more than 20 miles from the Napa County line, it is unlikely that the District's activities would occur within the boundaries of this HCP.

4.1.4.5 Bay Delta Conservation Plan

The BDCP is an HCP being developed as part of California's overall water management portfolio. It is being developed as a 50-year habitat conservation plan with the goals of restoring the Sacramento-San Joaquin River Delta (Delta) ecosystem and securing California water supplies. The plan area encompasses the legal Delta and surrounding areas (Solano, Yolo, Contra Costa, San Joaquin and Sacramento counties). It does not border Marin or Sonoma Counties, but does encompass parts of adjoining Solano County. The activities covered under the BDCP include improvements to water infrastructure facilities in and around the Delta and the protection of approximately 150,000 acres of habitat to address the Delta's environmental challenges. The BDCP includes 22 conservation measures

aimed at improving water operations, protecting water supplies and water quality, and restoring the Delta ecosystem within a stable regulatory framework (BDCP 2014).

The BDCP seeks coverage for 56 species and identifies conservation measures designed to contribute to their protection and recovery. The plan includes 67 goals and 165 objectives that form the basis of the conservation strategy, which includes landscape scale, natural community and biological and species specific goals and objectives. The BDCP also includes 37 AMMs that are incorporated into covered activities to minimize the effects of these actions on various resources. Many of these AMMs focus on minimizing the general environmental effects of construction activities and many others are species specific AMMs.

AMM 33 Mosquito Management calls for management and control of mosquitoes during construction of project facilities. The HCP Implementation Office will accomplish this through consultation with appropriate mosquito and vector control districts and will carry out mosquito control activities as necessary and applicable. The types of mosquito control activities that may be carried out under this AMM include surveillance, biological controls, physical controls, vegetation management, and use of larvicides and adulticides, as necessary.

4.1.4.6 Solano Habitat Conservation Plan

The Solano Habitat Conservation Plan is being developed by the Solano County Water Agency (SCWA) and will cover activities over a plan area of 577,000 acres in Solano County and 8,000 acres in Yolo County. The purpose of the Solano HCP is to (a) promote the conservation of biological diversity and the preservation of endangered species and their habitats consistent with the recognition of private property rights; (b) provide for a healthy economic environment for the citizens, agriculture, and industries; and (c) allow for the ongoing maintenance and operation of public and private facilities in Solano County. The plan is intended to cover activities undertaken by or under the permitting authority/control of the plan participants. Coverage may also be extended to third parties who fall under the direct regulatory control of the plan parties. The plan covers a number of natural communities and 36 covered species (SCWA 2102).

The Solano HCP would set up a reserve system with measurable biological standards to measure the overall success of the HCP conservation program. The plan specifies specific acreages of habitat to be established within the reserve system for different natural habitat types and species. Plan goals and objectives would be accomplished through implementation AMMs and mitigation measures. To obtain coverage under the Solano HCP will require that baseline studies be conducted for any proposed projects, the plan AMMs are implemented, and that the mitigation measures of the plan are carried out, when impacts do occur. AMMs include general measures for operation, maintenance and construction activities; habitat and covered species-specific AMMS; and special management species AMMS, with corresponding mitigation requirements for each covered resource.

4.1.4.7 Mendocino Redwood Company

Mendocino Redwood Company, LLC (MRC) is in the process of developing a HCP with the federal agencies (USFWS and NMFS), a NCCP with the CDFW, and a Program Timberland Environmental Impact Report with the California Department of Forestry and Fire Protection.

Timber management is the primary activity in the plan area, occurring on approximately 213,000 acres. Management activities include timber harvest and regeneration, site preparation, planting, vegetation management, thinning, and fire suppression.

The HCP/NCCP is MRC's operational plan for managing 11 federal or state threatened or endangered wildlife species, 31 rare plants, and 4 sensitive natural communities on the approximately 213,000-acre property located in coastal Mendocino County, California.

The plan, based on the Humboldt Redwood Company, LLC HCP/NCCP, provides for conservation measures for many endangered and threatened species (including spotted owls, marbled murrelets,

several salmonid species, rare mammals, amphibians, reptiles, and plants). The HCP requires large riparian buffers designed to provide tree canopy over streams for maintenance of cool water temperatures, filter strip properties, and abundant large wood for protection and enhancement of salmonid habitat. Management of these buffers over time should also increase the amount of old forest characteristics along these streams.

MRC's proposed 80-year term plan provides for the following outcomes: protect, enhance, and increase habitat for rare, threatened, or endangered species covered in the plan; mitigate the impact of land management on covered species; maintain and improve biodiversity in the covered area; contribute to the recovery of threatened and endangered species, and; attain "regulatory certainty" for endangered species management (MRC 2014.

As this HCP/NCCP is located in Mendocino County adjacent to Sonoma County and within approximately 2 miles of the county border, it is possible that the District's activities could occur within the HCP/NCCP boundaries.

4.1.4.8 Santa Rosa Plain Conservation Strategy (Regional)

The SRPCS is a long-term conservation program sufficient to mitigate potential adverse effects on five listed species (California tiger salamander, Burke's goldfield, Sonoma sunshine, Sebastopol meadowfoam, and many-flowered navarretia) due to future development on the Santa Rosa Plain. The Santa Rosa Plain (Sonoma County) is about 20 miles long (encompassing Windsor and Rohnert Park) and 6 miles wide (extending from Santa Rosa to Sebastopol). The goals are to:

> Develop a habitat conservation strategy that contributes to the recovery of California tiger salamander and listed plant species.

> Identify proposed areas for conservation.

> Develop an implementation framework for the conservation strategy which identifies short and long-term actions and milestones as needed.

> Establish development process predictability.

The strategy identified eight conservation areas, one tiger salamander preserve system, one listed plant preserve system, and one listed plant conservation area. Although local governmental agencies have not yet been able to complete the implementing ordinances for the strategy (USFWS 2013), the strategy is being implemented under the authority of a programmatic biological opinion (USFWS 2007 cited in USFWS 2013) and the oversight of an Implementation Committee, including representatives from local jurisdictions, USFWS, CDFW, and private landowners and the environmental community. Three conservation banks have been approved by the USFWS to date, and they continue to work to approve additional banks. The programmatic biological opinion simplifies the process of consulting with USFWS and complying with the federal Endangered Species Act by using a template in many circumstances, significantly shortening the permitting timeline.

The conservation program will contribute to the recovery of the Sonoma County populations of the five listed species and the conservation of their habitat within the conservation areas described above in a manner that protects stakeholders' (both public and private) land use interests, and supports issuance of an authorization for incidental take of California tiger. Project impacts may be mitigated with the purchase of mitigation credits in one of the USFWS-approved mitigation banks located on the Plain.

4.2 Environmental Impacts and Mitigation Measures

This section presents the environmental concerns associated with the various alternatives and presents significance criteria used to evaluate the likely impacts of the various Program alternatives under CEQA. The significance criteria establish thresholds for determining whether an impact rises to a level that is biologically significant. The environmental issues describe the mechanisms by which such impacts might occur.

4.2.1 Evaluation Concerns and Criteria

The Program alternatives are implemented as part of an IVMP as described in Section 2.3. The IVMP uses alternative nonchemical and chemical treatments in a sequential manner to minimize potential environmental impacts; evaluating each treatment site and situation and implementing the least harmful technique that is applicable for that situation consistent with IPM principles. Treatments with higher potential risk to the environment are only implemented when treatments with lower potential risk are ineffective or cannot be applied to that site. This approach minimizes the overall Program risk to the environment, but environmental concerns relating to the different alternatives remain.

4.2.1.1 Environmental Concerns

Some Program alternatives have the potential to affect aquatic resources directly by affecting physical habitat and through direct toxicity to nontarget organisms. The Program alternatives may also affect aquatic resources indirectly through effects on nontarget organisms that may affect food webs, making food less available.

Direct impacts would include habitat modifications, such as draining or changing the hydrology of waterways through removal of or placement of sediment and fill, removal of debris and weeds, and trimming or removal of emergent and riparian vegetation. The District may also request or require other landowners to perform similar activities. These activities may be undertaken in a variety of aquatic or wetland habitats including creeks and rivers, riparian corridors, ponds and lakes, freshwater marsh and seeps, seasonal wetlands, lagoons, tidal marsh and channels, as well as wastewater treatment and septic systems, temporary standing waters and artificial ponds.

Introduction of mosquito predators, specifically mosquitofish, into natural, and some artificial, environments could adversely affect nontarget organisms including insects, amphibians, and fish. Mosquitofish may prey upon these nontarget species directly or may compete with them for food resources.

Chemical control alternative options, including larvicides, adulticides, herbicides (under the Vegetation Management Alternative), and the biological agents (Bs), or their byproducts (Bti, and *Saccharopolyspora spinosa*), have the potential to affect nontarget organisms, either through direct toxicity or through effects on nontarget organisms, which could affect the food web. Similar types of effects could occur through the use of surfactants and adjuvants. The Program's potential to affect ecological health through impacts to nontarget ecological receptors is evaluated separately in Section 6.2 with an emphasis there on chemicals used or proposed for use as part of the District's IVMP.

Concerns identified during public scoping include the following, which are addressed as elements of the broader issues explained above:

> Employ techniques associated with the physical control of vectors and their habitat that conform to Habitat Conservation Plan (HCP) avoidance, minimization, and mitigation measures.

> Ensure mosquito abatement staff minimize impact to tidal marsh habitats (especially during breeding season).

> The PEIR should include a detailed description and complete assessment of the surveillance impacts (current and future, direct and indirect) on habitats (including endangered, threatened, and locally unique species and sensitive habitats) and on species (sensitive fish, wildlife, or plants).

> The PEIR should include a detailed description and complete assessment of the biological control impacts (current and future, direct and indirect) on habitats (including endangered, threatened, and locally unique species and sensitive habitats) and on species (sensitive fish, wildlife, or plants).

> The PEIR should include a detailed description and complete assessment of the chemical control impacts (current and future, direct and indirect) on habitats (including endangered, threatened, and locally unique species and sensitive habitats) and on species (sensitive fish, wildlife, or plants). This issue is also addressed in Section 6.2.

4.2.1.2 Significance Criteria

Significance criteria were developed based on applicable regulations and management policies, a review of the available information, and the professional judgment of the authors.

The CEQA Guidelines include several criteria for determining whether there is a potentially significant impact to biological resources in the CEQA Appendix G, Environmental Checklist Form, Section IV. Those that could apply to the Proposed Program as thresholds of significance for biological resources have been used in the following evaluation with the analysis organized according to these criteria as environmental topics. Impacts were considered potentially significant if they would:

a. Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the CDFW or USFWS.

b. Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations, or by the CDFW or USFWS.

c. Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act, (including but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means.

d. Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites.

e. Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance.

f. Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan.

4.2.2 Evaluation Methods and Assumptions

4.2.2.1 Evaluation Methods

Impacts are evaluated with regard to desired fish and amphibian species (e.g., native and listed species), macroinvertebrate communities, and effects on food supply for fish or amphibians, using the criteria described above as environmental topics. Potential impacts were assessed using available information on the types of control and treatment as described in Chapter 2, and assuming that all applicable BMPs as described in Chapter 2, Program Description; CDPH's Best Management Practices for Mosquito Control in California; the Statewide General NPDES Permit for Biological and Residual Pesticide Discharges to Waters of the US from Spray Applications (SWRCB Water Quality Order No. 2011-0004-DWQ; NPDES No. CAG 990007; Spray Applications Permit) and District-specific BMPs, as indicated in the PAPs and Aquatic Weed Control Permits (Aquatic Pesticide Application Plans [APAPs]), and all BMPs in Table 2-6, are implemented.

The BMPs most applicable to minimizing and/or avoiding impacts to aquatic resources are repeated in Table 4-6, which also indicates the habitat types in which those BMPs will be applied. This assessment considers the physical and biological connections between treatment areas and aquatic or wetland ecosystems. This information was evaluated in the context of the treatment alternatives and the existing environment under baseline conditions in 2012 in the Program Area as described in Section 4.1.1.

The detailed BMPs listed in Table 4-6 can be summarized and placed into several categories. These categories include:

1. Agency communication includes periodic discussion with resource agencies, refuge managers and other land managers on topics such as planning, specific site issues, special-status species occurrence, opportunities for source reduction, observations made by District staff (e.g., wildlife, trespass/unauthorized equipment use) and about activities to be implemented. This will include obtaining any required permits and reporting regarding existing permits, periodic check-in calls, and calls as needed, when unanticipated circumstances arise.
2. Environmental training includes environmental awareness training provided to all field staff regarding environmental resource issues, recognition, and documentation of sensitive environmental resources in the field, and BMPs to avoid or minimize impacts to those resources. This includes both general training, training to avoid or eliminate the spread of weeds, and special-status species or habitat specific training provided to District staff by USFWS, CDFW or other appropriately trained individuals approved by these agencies.
3. Pre-treatment screening involves a pre-treatment, in-office assessment of treatment locations for environmentally sensitive resources to determine appropriate treatment, access routes, and other BMPs to be applied for that location. This may include a pre-treatment site visit to confirm information used in the screening.
4. Disturbance minimization includes:
    a. avoiding environmentally sensitive areas as much as practical;
    b. use of existing access routes where ever possible, whether on foot or in a vehicle;
    c. minimizing use of offroad vehicles as much as possible, and driving slowly when they are used;
    d. being observant and working carefully to avoid or minimize disturbance; and,
    e. using hand tools rather than mechanized tools as much as practical for all vegetation clearing (including clearing of access ways) or physical control treatments.
5. Habitat or species-specific BMPs includes BMPs targeted to a specific habitat type or species (e.g., tidal marshes or salt marsh harvest mouse). These BMPs include measures specific to those habitat types or species including diurnal or seasonal limitations on specific project activities, specific controls on the types of activities or how they are carried out, Specific measures are those documented in Table 4-6.
6. Alternative specific BMPs relate specifically to the implementation of a particular treatment (Physical Control, Vegetation Management, Chemical Control). These may overlap many of the BMPs described above, but also include alternative-specific measures to protect environmental resources, based the type of activity to be conducted (e.g., protection of soil surface, minimization of turbidity under the Physical Control Alternative or adherence to label directions, treating only during periods with acceptable weather conditions, and employing appropriate buffers for Chemical Control).

These categories are not inclusive of all the BMPs in Chapter 2 or Table 2-6, **nor are they intended to replace those more specific BMPs**. These categories are provided to facilitate the discussion of the impact evaluation through the end of this chapter. The application of specific BMPs by alternative and habitat type is provided in Table 4-6. Table 4-6 lists all of the BMPs for Program implementation by alternative and habitat types that are relevant to biological resources and determinations of impact significance.

Impact determinations follow the analysis for each Program alternative and cover the following issues derived from the CEQA significance criteria (Section 4.2.1.2):

a. Impacts to special-status species

b. Impacts to riparian habitats or other sensitive natural communities

c. Impacts to federally protected wetlands

d. Impacts to movement of native resident or migratory fish or wildlife species.

e. Conflicts with to local policies

f. Conflicts with provisions of HCP, NCCP, or other approved habitat conservation plan

The potential effects of the treatment alternatives will vary depending on the specific treatment applied, the size and location of the treated area, the type of habitat treated, and the timing and frequency of treatment. Small treatment areas or less frequent applications of a treatment would generally be expected to result in lesser effects than the same treatment applied over a larger area or more frequently.

The potential impacts of the nonchemical alternatives are based on the type and location of habitats treated and the magnitude and frequency of treatment. The potential impacts of the chemical alternatives were evaluated based on the magnitude and duration of the treatments and the toxicity and application information presented in Chapter 6, Ecological Health, and Appendix B, Human and Ecological Health Assessment Report. The evaluation of all alternatives considered the life histories of the different listed fish and amphibian species and ecological interactions including impacts to the aquatic food chain.

The pesticide application scenarios that result in reasonable efficacy with minimal unwanted estimated risk are preferred and are the basis of IPM approaches and BMPs the District employs. BMPs are contained in Chapter 2, Section 2.9 and associated with habitat types in which they would be applied in Table 4-6. Each of the pesticides and herbicides identified as warranting further evaluation in Appendix B (as a subset of all pesticides and herbicides in use) are known to exhibit at least one parameter that appears to have a significant role in the resulting potential or perceived risk.

4.2.2.2 Assumptions

The following assumptions were used in the assessment of potential aquatic resource impacts from the Program alternatives:

> Site-specific evaluation of aquatic resource impacts is not within the scope of this programmatic evaluation. Rather, the analysis uses habitat types likely to be affected by any of the alternatives as the basis for evaluation.

> The programmatic evaluation is based on the current proposed control methods and is subject to change based on future needs (see Section 1.8).

> The BMPs listed in Table 4-6 will be implemented by District staff as appropriate to the type of activity under the Program alternatives.

Table 4-6 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid / Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other	Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Tree Holes	Creeks and Rivers	Riparian Corridor	Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	FW Marsh/Seeps	Seasonal Wetlands (includes Vernal Pools)	Lagoon	Tidal Marsh and channels	Water and Wastewater Management Facilities	Artificial Containers, Temporary Standing Waters and Ornamental Ponds
A. General BMPs																						
1. District staff has had long standing and continues to have cooperative, collaborative relationships with federal, state, and local agencies. The District regularly communicates with agencies regarding the District's operations and/or the necessity and opportunity for increased access for surveillance, source reduction, habitat enhancement, and the presence of special-status species and wildlife. The District often participates in and contributes to interagency projects. The District will continue to foster these relationships, communication, and collaboration.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2. In particular, District staff will regularly communicate with resource agency staff regarding vector management operations, habitat, and flora and fauna in sensitive habitats. Such communications will include wildlife studies and occurrences of special-status species in areas that may be subject to vector management activities.	X	X	X	*	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X
3. When walking or using small equipment in marshes, riparian corridors, or other sensitive habitats, existing trails, levees and access roads will be used whenever possible to minimize or avoid impacts to species of concern and sensitive habitats. Specific care will be taken when walking and performing surveillance in the vicinity of natural and manmade ditches or sloughs or in the vicinity of tidal marsh habitat.	X	X	X	*[1]	X	X								X	X	X	X	X	X	X		
4. District staff has received training from USFWS and CDFW biologists regarding endangered species, endangered species habitat, and wildlife/wildlife habitat recognition and avoidance measures. District supervisory staff frequently engages staff on these subjects. For example, District staff has become familiar with Ridgway's rail call recordings to invoke avoidance measures if these calls are heard in the field. District staff is trained to be observant, proceed carefully, and practice avoidance measures if needed when accessing areas that may serve as bird nesting habitat (e.g., watch for flushing birds that may indicate a nest is nearby). Emphasis will be placed on species and habitats of concern where vector management activities might occur (e.g., SMHM, RIRA, special-status plants, vernal pools, tidal marsh, etc.). These training sessions will be included as a part of the safety training records that are kept by vector control agencies.	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

[1] (*) means not available at this time. Should a viable biocontrol agent become available, evaluation of BMP measures would occur and be implemented.

Table 4-6 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid / Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other	Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Tree Holes	Creeks and Rivers	Riparian Corridor	Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	FW Marsh/Seeps	Seasonal Wetlands (includes Vernal Pools)	Lagoon	Tidal Marsh and channels	Water and Wastewater Management Facilities	Artificial Containers, Temporary Standing Waters and Ornamental Ponds
5. Conduct worker environmental awareness training for all treatment field crews and contractors for special-status species and sensitive natural communities that a qualified person (e.g., District biologist) determines to have the potential to occur on treatment sites. Conduct the education training prior to starting work at treatment sites and upon arrival of any new worker onto sites with the potential for special-status species or sensitive natural communities.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6. District staff will work with care and caution to minimize potential disturbance to wildlife while performing surveillance and vector treatment/population management activities (see 1 through 5 above).	X	X	X	*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7. Identify probable (based on historical experience) treatment sites that may contain habitat for special-status species every year prior to work to determine the potential presence of special-status flora and fauna using the CNDDB, relevant Habitat Conservation Plans (HCPs), NOAA Fisheries and USFWS websites, Calfish.org, and other biological information developed for other permits. Establish a buffer of reasonable distance, when feasible, from known special-status species locations and do not allow application of pesticides/herbicides within this buffer without further agency consultations. Nonchemical methods are acceptable within the buffer zone when designed to avoid damage to any identified and documented rare flora and fauna.	X	X	X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8. Vehicles driving on levees to travel through tidal marsh or to access sloughs or channels for surveillance or treatment activities will travel at speeds no greater than 10 miles per hour to minimize noise and dust disturbance.	X	X	X		X	X														X		
9. District staff will implement site access selection guidelines to minimize equipment use in sensitive habitats including active nesting areas and to use the proper vehicles for on-road and off-road conditions.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
10. Properly train all staff, contractors, and volunteer help to prevent spreading weeds and pests to other sites. The District headquarters contains wash rack facilities (including high-pressure washers) to regularly (in many cases daily) and thoroughly clean equipment to prevent the spread of weeds.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
11. Operation of noise-generating equipment (e.g., chainsaws, wood chippers, brush-cutters, pickup trucks) will abide by the time-of-day restrictions established by the applicable local jurisdiction (i.e., City and/or County) if such noise activities would be audible to receptors (e.g., residential land uses, schools, hospitals, places of worship) located in the applicable local jurisdiction. Shut down all motorized equipment when not in use.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 4-6 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid / Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other	Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Tree Holes	Creeks and Rivers	Riparian Corridor	Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	FW Marsh/Seeps	Seasonal Wetlands (includes Vernal Pools)	Lagoon	Tidal Marsh and channels	Water and Wastewater Management Facilities	Artificial Containers, Temporary Standing Waters and Ornamental Ponds
12. For operations that generate noise expected to be of concern to the public, the following measures will be implemented: – Measure 1: Provide Advance Notices: A variety of measures are implemented depending on the magnitude/nature of the activities undertaken by the District, and may include but are not limited to press releases, social media, District websites, emails, phone messages, hand-delivered flyers, and posted signs. Public agencies and elected officials also may be notified of the nature and duration of the activities, including the Board of Supervisors or City Council, environmental health and agricultural agencies, emergency service providers, and airports. – Measure 2: Provide Mechanism to Address Complaints. The District staff is available during regular business hours to respond to service calls and may staff phone lines to address concerns during nighttime operations.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
13. The District will perform public education and outreach activities.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
14. Engine idling times will be minimized either by shutting equipment and vehicles off when not in use or reducing the maximum idling time to 5 minutes. Clear signage will be provided for workers at all access points. Correct tire inflation will be maintained in accordance with manufacturer's specifications on wheeled equipment and vehicles to prevent excessive rolling resistance. All equipment and vehicles will be maintained and properly tuned in accordance with manufacturer's specifications. All equipment will be checked by a certified visible emissions evaluator if visible emissions are apparent to onsite staff.	X	X	X	X	X	X																

Table 4-6 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid / Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other	Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Tree Holes	Creeks and Rivers	Riparian Corridor	Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	FW Marsh/Seeps	Seasonal Wetlands (includes Vernal Pools)	Lagoon	Tidal Marsh and channels	Water and Wastewater Management Facilities	Artificial Containers, Temporary Standing Waters and Ornamental Ponds
B. Tidal Marsh-Specific BMPs																						
1. District staff will continue to implement the measures in the USFWS's "Walking in the Marsh: Methods to Increase Safety and Reduce Impacts to Wildlife/Plants." District staff will receive annual training and review of this document to remain up to date and current on this document and its methodologies for protecting special-status species and the marsh habitat.	X	X	X	*	X														X	X		
2. District will minimize the use of equipment (e.g., ARGOs) in tidal marshes and wetlands. When feasible and appropriate, surveillance and control work will be performed on-foot with handheld equipment. Aerial treatment (helicopter and fixed wing) treatments will be utilized when feasible and appropriate to minimize the disturbance of the marsh during pesticide applications. When ATVs (e.g., ARGOs) are utilized techniques will be employed that limit impacts to the marsh including: slow speeds; slow, several point turns; using existing levees or upland to travel through sites when possible; use existing pathways or limit the number of travel pathways used.	X	X	X	*	X	X													X	X		
3. District will minimize travel along tidal channels and sloughs in order to reduce impacts to vegetation used as habitat (e.g., Ridgway's Rail nesting and escape habitat).	X	X	X		X														X	X		
4. District staff will minimize the potential for the introduction and spread of spartina, perennial pepperweed and other invasive plant species by cleaning all equipment, vehicles, personal gear, clothing, and boots of soil, seeds, and plant material prior to entering the marsh, and avoiding walking and driving through patches of perennial pepperweed to the maximum extent feasible.	X	X	X	*	X	X								X[1]		X[1]	X[1]	X[1]	X	X		
5. When feasible, boats will be used to access marsh areas for surveillance and treatment of vectors to further reduce the risk of potential impacts that may occur when using ATVs to conduct vector management activities.	X	X	X	*	X														X	X		

Table 4-6 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid / Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other	Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Tree Holes	Creeks and Rivers	Riparian Corridor	Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	FW Marsh/Seeps	Seasonal Wetlands (includes Vernal Pools)	Lagoon	Tidal Marsh and channels	Water and Wastewater Management Facilities	Artificial Containers, Temporary Standing Waters and Ornamental Ponds
6. The District currently references and provides staff training relevant to the USFWS "Walking in the Marsh: Methods to Increase Safety and Reduce Impacts to Wildlife/Plants" guidelines (USFWS undated). – District staff is trained to walk carefully in the marsh and to continuously look ahead of themselves to avoid potential wildlife disturbance (e.g., carefully make observations in their surroundings to detect flushing birds and nests). Specific care is taken when walking and performing surveillance in the vicinity of natural and manmade ditches or sloughs or in vicinity of cord grass habitat (e.g., rack line). – When walking in marshes District staff utilizes existing trails when possible (i.e., deer trails and other preexisting trails).	X	X	X	X	X	X	X[2]	X[2]	X[2]	X[2]	X[2]	X[2]		X[2]			X[2]	X[2]	X	X		
C. Salt Marsh Harvest Mouse (SMHM)																						
1. Activities (surveillance, treatment, source reduction) within or adjacent to harvest mouse habitat will not occur within two hours before or after extreme high tides of 6.5 feet National Geodetic Vertical Datum (NGVD) or above as measured at the Golden Gate Bridge (corrected for time and tide height for the site) or when the marsh plain is completely inundated because suitable upland refugia cover is limited and potentially disturbance-creating activities could prevent mice from reaching available cover.	X	X	X	*	X	X													X	X		
2. Vegetation removal is limited to the minimum amount necessary to allow for surveillance, treatment, and vector habitat reduction (vegetation management) to minimize or avoid loss of SMHM. Similarly, excavation, fill, or construction activities will also be limited to the minimum amount necessary to minimize/avoid loss of SMHM.	X	X	X		X														X	X		
3. Vegetation clearing will be conducted systematically within the project area to ensure that SMHM are encouraged to move toward remaining vegetation and are not trapped in islands of vegetation subject to removal and far from suitable cover.		X	X																X	X		
4. Each day, 30 minutes before commencement of vector habitat management (physical control, vegetation management), observations will be conducted for the presence of SMHM in the work area by staff trained by USFWS personnel in the safe and effective methods for observing SMHM.		X	X	*	X														X	X		

Table 4-6 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid / Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other	Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Tree Holes	Creeks and Rivers	Riparian Corridor	Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	FW Marsh/Seeps	Seasonal Wetlands (includes Vernal Pools)	Lagoon	Tidal Marsh and channels	Water and Wastewater Management Facilities	Artificial Containers, Temporary Standing Waters and Ornamental Ponds
5. To the extent feasible, physical control, vegetation management and other vector habitat reduction activities will be conducted between December 1 and February 28 (outside of the SMHM breeding season). Surveillance, chemical control, biological control, and public education activities occur year-round and are therefore carefully coordinated with resource agencies to minimize potential impacts to SMHMs and their habitats.		X	X		X														X	X		
6. When walking in the marsh, existing trails will be used whenever possible. Specific care will be taken when walking and performing surveillance in the vicinity of natural and manmade ditches or sloughs or in the vicinity of tidal marsh habitat to avoid potential disturbance of SMHM.	X	X	X	*	X	X													X	X		
7. District staff will receive training on measures to avoid impacts to SMHM.	X	X	X	*	X	X													X	X		
8. If SMHM nests or adults are encountered during vector management activities, avoidance measures will be immediately implemented and findings will be reported to the appropriate resource agency.	X	X	X	*	X	X													X	X		
D. Ridgway's Rail (RIRA)																						
1. Activities (surveillance, treatment, source reduction) within or adjacent to RIRA's habitat will not occur within two hours before or after extreme high tides of 6.5 feet National Geodetic Vertical Datum (NGVD) or above as measured at the Golden Gate Bridge (corrected for time and tide height for the site) or when the marsh plain is completely inundated because suitable upland refugia cover is limited and potentially disturbance-creating activities could prevent RIRAs from reaching available cover.	X	X	X	*	X	X													X	X		
2. Vegetation removal is limited to the minimum amount necessary to allow for surveillance, treatment, and vector habitat reduction (vegetation management) to minimize or avoid loss of RIRA. Similarly, excavation, fill, or construction activities will also be limited to the minimum amount necessary to minimize/avoid loss of RIRA.	X	X	X		X														X	X		
3. To the extent feasible, physical control, vegetation management and other vector habitat reduction activities will be conducted between September 1 and January 31 (outside of the RIRA breeding season). Surveillance, chemical control, biological control, and public education activities occur year-round and are therefore carefully coordinated with resource agencies to minimize potential impacts to RIRAs and their habitats.		X	X		X														X	X		

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Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
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4. District staff will notify the appropriate resource agency prior to entering potential RIRA habitats and will regularly coordinate with the resource agency(ies) on the locations of breeding RIRAs and avoid breeding RIRAs to the extent feasible. Any observations of adverse effects to RIRAs will be reported by District staff.	X	X	X	X	X														X	X		
5. When walking in the marsh District staff will use existing trails whenever possible. Specific care will be taken when walking and performing surveillance in the vicinity of natural and manmade ditches or sloughs or in the vicinity of tidal marsh habitat to avoid potential disturbance of RIRAs.	X	X	X	*	X	X													X	X		
6. Entry into suitable breeding habitat for RIRAs will be minimized. When entry is required, the preferred method will be by foot. Other entry methods will be based on consultation with the appropriate resource agency.	X	X	X	*	X	X													X	X		
7. District staff will receive training on measures to avoid impacts to RIRAs	X	X	X	*	X	X													X	X		
8. If RIRA nests or adults are encountered during vector management activities, avoidance measures, as provided during training from the resource agencies, will be immediately implemented and findings will be reported to the appropriate resource agency.	X	X	X	*	X	X													X	X		
E. Soft Bird's Beak																						
1. District staff will receive training on the identification, biology and preferred habitat of soft bird's beak.	X	X	X	*	X	X													X	X		
2. When possible, project actions to be conducted in areas containing suitable habitat for this species will occur during the time period when soft bird's beak is in bloom and identifiable (July-November), so that any soft bird's beaks plants observed can be avoided and documented.	X	X	X	*	X	X													X	X		
3. District staff will coordinate with Napa-Sonoma Marshes Wildlife Area (CDFW) and San Pablo Bay National Wildlife Refuge regarding the locations of known soft bird's beak populations, so that these populations can be avoided. Flagging will be used to identify the boundaries of known soft bird's beak populations.	X	X	X	*	X	X													X	X		
4. When possible, vector management activities will be conducted on foot using hand equipment.	X	X	X	*	X	X													X	X		

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F. Vegetation Management																						
1. Consultations will be made with the appropriate resource agency to discuss proposed vegetation management work, determine potential presence of special-status species and areas of concern, and any required permits.		X	X											X	X	X	X	X	X	X		
2. Vegetation management work performed will typically be by hand, using handheld tools, to provide access to vector habitat for surveillance, and when needed control activities. Tools used include machetes, small garden-variety chainsaw, hedge trimmers and "weed-eaters."		X	X											X	X	X	X	X	X	X		
3. District will consult and coordinate with resource agencies as well as have all necessary permits prior to the commencement of work using heavy equipment (e.g., larger than handheld/garden variety tools such as small excavators with rotary mowers) in riparian areas.		X	X											X	X	X	X	X	X	X		
4. Minor trimming of vegetation (e.g., willow branches approximately three inches in diameter or less, blackberry bushes, and poison oak) to the minimum extent necessary will occur to maintain existing paths or create access points through dense riparian vegetation into vector habitat. This may include minor trimming of overhanging limbs, brush and blackberry thickets that obstruct the ability to walk within creek channels. Paths to be maintained will not be a cut, defined corridor but rather a path maintained by selective trimming of overhanging or intrusive vegetation. Paths to be maintained will range in width from three to 6 feet across.		X	X												X							
5. Downed trees and large limbs that have fallen due to storm events or disease will be cut only to the extent necessary to maintain existing access points or to allow access to vector habitats.		X	X												X							
6. Vegetation management work will be confined to October 1 to April 30[2] to minimize potential impacts to special-status species, especially breeding birds. When work is expected to occur between February 1 and April 30, additional consultations will occur with appropriate resource agencies to help identify locations of active nests of raptors or migratory birds as well as any additional protection measures that will need to be implemented prior to commencement of work.		X	X												X	X	X	X	X	X		

[2] Dates are from MSMVCD's Final LSAA permit with CDFW; Notification No. 1600-2010-2053-R3, Public Health/Mosquito Control Access Maintenance (October 6, 2010).

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7. Every effort will be made to complete vegetation management in riparian corridors prior to the onset of heavy rains. Maintenance work to be done in early spring will be limited to trimming new growth, poison oak, blackberries, and downed trees that block these paths.		X	X												X							
8. District staff will work with care and caution to minimize potential disturbance to wildlife, while performing vegetation management activities within or near riparian corridors.		X	X											X	X	X	X	X	X	X		
9. Within suitable habitat for California Freshwater Shrimp (*Syncaris pacifica*), no in-channel vegetation will be removed, trimmed, or otherwise disturbed. District staff will work with resource agencies to determine locations of suitable habitat for California Freshwater Shrimp and receive written authorization to proceed prior to commencement of vegetation management activities.		X	X											X	X							
10. If suitable habitat necessary for special-status species is found, including vernal pools, and if nonchemical physical and vegetation management control methods have the potential for affecting special-status species, then the District will coordinate with the CDFW, USFWS, and/or NMFS before conducting control activities within this boundary or cancel activities in this area. If the District determines no suitable habitat is present, control activities may occur without further agency consultations.		X	X											X	X	X	X	X	X	X		
11. When using heavy equipment for vegetation management, District staff (and contractors) will minimize the area that is affected by the activity and employ all appropriate measures to minimize and contain turbidity. Heavy equipment will not be operated in the water and appropriate containment and cleanup systems will be in place on site to avoid, contain, and clean up any leakage of toxic chemicals.		X	X											X	X	X	X	X	X	X		
G. Maintenance / Construction and Repair of Tide Gates and Water Structures in Waters of the US																						
1. District staff will consult with appropriate resource agencies (USACE, USFWS, CDFW, NMFS, BCDC, RWQCB) and obtain all required permits prior to the commencement of ditch maintenance or construction within tidal marshes.		X												X		X	X	X	X	X	X	

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Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
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2. Work plans for the upcoming season proposed work as well as a summary of the last season completed work will be submitted for review and comment to USACE, USFWS, NMFS, CDFW, BCDC, and RWQCB no later than July 1 of each year for which work is being proposed. The work plan will include a delineation of all proposed ditching overlain on topographic maps at a minimum of 1" = 1000' scale, with accompanying vicinity maps. The plan will also indicate the dominant vegetation of the site, based on subjective estimates, the length and width of the ditches to be maintained, cleared or filled, and the estimated date the work will be carried out.		X												X		X	X	X	X	X	X	
3. All maintenance work will be done at times that minimize adverse impacts to nesting birds, anadromous fish, and other species of concern, in consultation with USFWS, NMFS, and CDFW. Work conducted will, whenever possible, be conducted during approved in water work periods for that habitat, considering the species likely to be present. For example, tidal marsh work will be conducted between September 1 and January 31, where possible and not contraindicated by the presence of other special-status species. Similarly, in water work in waterbodies that support anadromous fish, work will be conducted between July 1 and September 30.[3]		X	X											X		X	X	X	X	X	X	
4. Care will be taken to minimize the risk of potential disruption to the indigenous aquatic life of a waterbody in which ditch maintenance is to take place, including those aquatic organisms that migrate through the area.		X												X		X	X	X	X	X	X	
5. Staging of equipment will occur on upland sites.		X												X		X	X	X	X	X	X	
6. Mats or other measures taken to minimize soil disturbance (e.g., use of low ground pressure equipment) when heavy equipment is used.		X												X		X	X	X	X	X	X	
7. All projects will be evaluated prior to bringing mechanical equipment on site, in order to identify and flag sensitive sites, select the best access route to the work site consistent with protection of sensitive areas, and clearly demarcate work areas.		X												X		X	X	X	X	X	X	
8. Measures will be taken to minimize impacts from mechanical equipment, such as hand ditching as much as possible; reducing turns by track-type vehicles, taking a minimum number of passes with equipment, varying points of entry, driving vehicles at low speed, and not driving on open mud and other soft areas.		X												X		X	X	X	X	X	X	

[3] Dates are from District's USACE. Regional Permit 4, July 31, 2007.

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9. Discharges of dredged or fill material into tidal waters will be minimized or avoided to the maximum extent possible at the project site and will be consistent with all permit requirements for such activity. No discharge of unsuitable material (e.g., trash) will be made into waters of the United States, and material that is discharged will be free of toxic pollutants in toxic amounts (see Section 307 of the Clean Water Act). Measures will be taken to avoid disruption of the natural drainage patterns in wetland areas.		X												X		X	X	X	X	X	X	
10. Discovery of historic or archeological remains will be reported to USACE and all work stopped until authorized to proceed by the appropriate regulatory authorities/resource agencies.		X												X		X	X	X	X	X	X	
11. Ditching that drains high marsh ponds will be minimized to the extent possible in order to protect the habitat of native salt pan species.		X																	X	X		
12. No spoils sidecast adjacent to circulation ditches will exceed 8 inches above the marsh plain to minimize risk of colonization of spoils by invasive, nonnative plants and/or the spoils lines from becoming access corridors for unwanted predators (e.g., dogs, cats, red fox). Sidecast spoil lines exceeding 4 inches in height above the marsh plain will extend no more than 6 feet from the nearest ditch margin. Any spoils in excess of these dimensions will be hydraulically redispersed on site (e.g., by rotary ditcher), or removed to designated upland sites (per conditions of resource agency issued permits). Sidecast spoil lines will be breached at appropriate intervals to prevent local impediments to water circulation.		X																	X	X		
13. If review of the proposed work plan by USACE, USFWS, or CDFW determines the proposed maintenance is likely to destroy or damage substantial amounts of shrubby or sub-shrubby vegetation (e.g., coyote brush, gumplant) on old sidecast spoils, the District will provide a quantitative estimate of the extent and quality of the vegetation, and provide a revegetation plan for the impacted species prepared by a biologist/botanist with expertise in marsh vegetation. The Corps approved revegetation plan will be implemented prior to April 1 of the year following the impacts.		X																	X	X		
14. Small ditch maintenance work will be performed by hand, whenever possible, using handheld shovels, pitch forks, etc., and small trimmers such as "weed-eaters." (Note: the majority of small ditch work performed by the District is by hand.)		X														X	X	X	X	X	X	
15. Work will be done at low tide (for tidal areas) and times of entry will be planned to minimize disruption to wildlife.		X												X	X	X	X	X	X	X	X	

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16. In marshes which contain populations of invasive nonnative vegetation such as pepperweed or introduced spartina, sidecast spoils will be surveyed for the frequency of establishment of these species during the first growing season following deposition of the spoils. The results of the surveys will be reported to the USACE, USFWS and CDFW. If it is determined the sidecasting of spoils resulted in a substantial increase in the distribution or abundance of the nonnative vegetation which is detrimental to the marsh, the District will implement appropriate abatement measures after consultation with the USACE, USFWS and CDFW.		X																	X	X		
17. When possible (i.e., with existing labor and vehicles), refuse such as tires, plastic, and man-made containers found at the work site will be removed and properly discarded.		X	X											X		X	X	X	X	X	X	
H. Applications of Pesticides, Surfactants, and/or Herbicides																						
1. District staff will conduct applications with strict adherence to product label directions that include approved application rates and methods, storage, transportation, mixing, and container disposal.			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2. District will avoid use of surfactants when possible in sites with aquatic nontargets or natural enemies of mosquitoes present such as nymphal damsel flies and dragonflies, dytiscids, hydrophilids, corixids, notonectids, and ephydrids. Surfactants are the only tool that can be used with pupae to prevent adult mosquitos emergence, but generally the District will use a microbial larvicide (Bti, Bs) or insect growth regulator (e.g., methoprene) instead or another alternative when possible.			X		X								X	X	X	X	X	X	X	X	X	X
3. Materials will be applied at the lowest effective concentration for a specific set of vectors and environmental conditions. Application rates will never exceed the maximum label application rate.			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4. To minimize application of pesticides, application of pesticides will be informed by surveillance and monitoring of vector populations.			X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5. District staff will follow label requirements for storage, loading, and mixing of pesticides and herbicides. Handle all mixing and transferring of herbicides within a contained area.			X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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6. Postpone or cease application when predetermined weather parameters exceed product label specifications, when wind speeds exceed the velocity as stated on the product label, or when a high chance of rain is predicted and rain is determining factor on the label of the material to be applied.			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7. Applicators will remain aware of wind conditions prior to and during application events to minimize any possible unwanted drift to waterbodies, and other areas adjacent to the application areas.			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8. Spray nozzles will be adjusted to produce larger droplet size rather than smaller droplet size. Use low nozzle pressures where possible (e.g., 30 to 70 pounds per square inch). Keep spray nozzles within a predetermined maximum distance of target weeds (e.g., within 24 inches of vegetation for hand application) or vectors. Adjusting droplet size would only apply to larvicides, herbicides and non-ULV applications. Use ULV applications that are calibrated to be effective and environmentally compatible at the proper droplet size (about 10-30 microns).			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9. Clean containers at an approved site and dispose of at a legal dumpsite or recycle in accordance with manufacturer's instructions if available.			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
10. Special-Status Aquatic Wildlife Species: – A CNDDB search was conducted in 2012 and the results incorporated into Appendix A for this PEIR. An update was completed in November 2014 and the results incorporated into Section 4.1.2 of this PEIR. District staff communicates with state, federal, and county agencies regarding sites that have potential to support special-status species. Many sites where the District performs surveillance and control work have been visited by staff for many years and staff is highly knowledgeable about the sites and habitat present. If new sites or site features are discovered that have potential to be habitat for special-status species, the appropriate agency or landowner is contacted and communication initiated. – Use only pesticides, herbicides, and adjuvants approved for aquatic areas or manual treatments within a predetermined distance from aquatic features (e.g., within 15 feet of aquatic features). Aquatic features are defined as any natural or man-made lake, pond, river, creek, drainage way, ditch, spring, saturated soils, or similar feature that holds water at the time of treatment or typically becomes inundated during winter rains.			X	*	X									X		X	X	X	X	X	X	

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– If suitable habitat for special-status species is found, including vernal pools, and if aquatic-approved pesticide, herbicide, and adjuvant treatment methods have the potential for affecting the potential species, then the District will coordinate with the CDFW, USFWS, and/or National Marine Fisheries Service (NMFS) before conducting treatment activities within this boundary or cancel activities in this area. If the District determines no suitable habitat is present, treatment activities may occur without further agency consultation.																						
11. District staff will monitor sites post-treatment to determine if the target vector or weeds were effectively controlled with minimum effect to the environment and nontarget organisms. This information will be used to help design future treatment methods in the same season or future years to respond to changes in site conditions.			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
12. Do not apply pesticides that could affect insect pollinators in liquid or spray/fog forms over large areas (more than 0.25 acres) during the day when honeybees are present and active or when other pollinators are active. Preferred applications of these specific pesticides are to occur in areas with little or no honeybee or pollinator activity or after dark. These treatments may be applied over smaller areas (with handheld equipment), but the technician will first inspect the area for the presence of bees and other pollinators. If pollinators are present in substantial numbers, the treatment will be made at an alternative time when these pollinators are inactive or absent.			X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
13. The District will provide notification to the public (24 to 48 hours in advance if possible) and/or appropriate agency(ies) when applying pesticides or herbicides for large-scale treatments (e.g., fixed-wing aircraft or helicopters) that will occur in close proximity to homes, heavily populated, high traffic, and sensitive areas. The District infrequently applies or participates in the application of herbicides in areas other than District facilities.			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
I. Hazardous Materials and Spill Management																						
1. Exercise adequate caution to prevent spillage of pesticides during storage, transportation, mixing or application of pesticides. Report all pesticide spills and cleanups (excepting cases where dry materials may be returned to the container or application equipment).			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2. Maintain a pesticide spill cleanup kit and proper protective equipment at the District's Service Yard and in each District truck used for pesticide transport.			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

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3. Manage the spill site to prevent entry by unauthorized personnel. Contain and control the spill by stopping it from leaking or spreading to surrounding areas, cover dry spills with polyethylene or plastic tarpaulin, and absorb liquid spills with appropriate absorbent materials.			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4. Properly secure the spilled material, label the bags with service container labels identifying the pesticide, and deliver them to a District/Field Supervisor for disposal.			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5. A hazardous spill plan will be developed, maintained, made available, and staff trained on implementation and notification for petroleum-based or other chemical-based materials prior to commencement of vector treatment activities.	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6. Field-based mixing and loading operations will occur in such a manner as to minimize the risk of accidental spill or release of pesticides.			X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

[1] This BMP would also be applied in aquatic habitats other than tidal marshes, although the weed species of concern would differ.

[2] This BMP would also be applied in all habitats.

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This aquatic resources evaluation does not incorporate any assumptions about which alternative treatment strategy or strategies (options) would be applied in any given area. Therefore, each treatment alternative is considered as a stand-alone option, although the Program may include multiple alternative treatments within a given area, i.e., physical controls followed by larvicide application. This evaluation assumes that all chemical treatments would be made in accordance with label instructions and guidance provided by the USEPA and CDPR (and in consideration of the local context for that area, i.e., nearby area land uses and habitats). Guidelines used to trigger a particular alternative based on vector abundance and other variables are included in District-specific operating procedures. This evaluation assumes that important parameters such as sediment half-life are dependent on the specific conditions at the time of pesticide application; therefore, the values listed herein serve as reference values. The USEPA requires mandatory statements on pesticide product labels that include directions for use; precautions for avoiding certain dangerous actions; and where, when, and how the pesticide should be applied. This guidance is designed to ensure proper use of the pesticide and prevent unreasonable adverse effects to humans and the environment. All pesticide labels are required to include the name and percentage by weight of each active ingredient in the product/formulation. Toxicity categories for product hazards and appropriate first-aid measures must be properly and prominently displayed. Pesticide labels also outline proper use, storage, and disposal procedures, as well as precautions to protect applicators. The directions for use specify the target organism, appropriate application sites, application rates or dosages, contact times, and required application equipment for the pesticide. Warnings regarding appropriate wind speeds, droplet sizes, or habitats to avoid during application are also prominently displayed.

Concerning the application of multiple chemical treatments in the same area, such as larvicides followed by adulticides (i.e., not likely to occur under normal circumstances), or the application of multiple pesticides at the same time in a specific area (e.g., usually multiple active ingredients in the formulation such as VectoMax which combines Bti and Bs), the following information applies:

> Most products sold as herbicides and pesticides are evaluated herein both for the active ingredient and for the adjuvants and surfactants used to make the product more useful. When multiple products are used in a vector control application, the impacts are weighed against the proximity and timing of each application. If products with similar or even different active ingredients are applied simultaneously, it is likely that the net effect could be the sum of the effects of the active ingredients to impact the vector. However, for vector control applications materials with the same active ingredient are not applied to the same specific area or simultaneously at a given site. The need for reapplication of mosquito larvicides or adulticides is surveillance driven and performed per the label directions. The District can apply larvicide materials with different active ingredients during a single application. This type of application is necessary if multiple hatches of mosquito larvae occur and results in mosquito populations occurring at different stages of the life cycle. An example of this occurs when liquid Bti and methoprene are applied simultaneously. When this occurs the combination of the material is a product called Duplex, and the mixture of the materials and active ingredients is provided for on the product label. Another example for the District includes a pre-application of a liquid trans allethrin and phenothrin spray product may be used to minimize the hazard of approaching a yellow jacket nest. Situations that would produce a residual exposure adequate to cause harm to humans would not occur unless the application(s) were inappropriate or the timing of applications is inappropriately close. Actual applications do not generally occur that close together unless there is a problem with treatment effectiveness. A material is applied followed by post treatment inspection to determine effectiveness. Only if the vectors (mosquitoes) have not been sufficiently killed would the District go back into the area and reapply a pesticide.

Assumptions and/or background material related to the analysis of hazards, toxicity, and exposure for chemical treatment methods are explained below, including the definition of key terms. The ecological food web concept is explained as well, and it is addressed primarily in Section 6.2.2.2, Assumptions, along with the potential for bioaccumulation and biomagnification in the environment. Background information on bioaccumulation and biomagnification is provided in Section 6.1.1.3, the analyses of the chemicals with potential for bioaccumulation are covered in Sections 6.2.5 and 6.2.7.

4.2.2.3 Hazardous Material

A “hazardous material” is defined in California Health and Safety Code Section 25501 (p): as “any material that, because of its quantity, concentration, or physical or chemical characteristics, poses a significant present or potential hazard to human health and safety or to the environment if released into the workplace or the environment. “Hazardous materials" include, but are not limited to, “hazardous substances, hazardous waste, and any material that a handler or the administering agency has a reasonable basis for believing that it would be injurious to the health and safety of persons or harmful to the environment if released into the workplace or the environment.” Any liquid, solid, gas, sludge, synthetic product, or commodity that exhibits characteristics of toxicity, ignitability, corrosiveness, or reactivity has the potential to be considered a “hazardous material.”

4.2.2.4 Toxicity and Exposure

Toxicology is the study of a compound’s potential to elicit an adverse effect in an organism. The toxicity of a compound is dependent upon exposure, including the specific amount of the compound that reaches an organism’s tissues (i.e., the dose), the duration of time over which a dose is received, the potency of the chemical for eliciting a toxic effect (i.e., the response), and the sensitivity of the organism receiving the dose of the chemical. Toxicity effects are measured in controlled laboratory tests on a dose/response scale, in which the probability of a toxic response generally increases as the dose increases. Exposure to a compound is necessary for potential toxic effects to occur. However, exposure does not, in itself, imply that toxicity will occur in all circumstances. Thus, toxic and adverse effects can be mitigated by limiting potential exposure to a dose less than the amount that may result in adverse health effects.

The toxicity data included in the tables and charts in this PEIR are generally derived from rigidly controlled laboratory animal studies designed to determine the potential adverse effects of the chemical under several possible routes of exposure. In these studies, the species of interest is exposed to 100 percent chemical at several doses to determine the lowest concentration resulting in a predetermined adverse effect (LOAEL) on numerous selected physiological and behavioral systems. The second component of these tests is to determine the highest concentration of chemical that results in no measurable adverse effect (NOAEL). These two levels are used to describe the potential range of exposures that could result in adverse effects, including the highest dose with no observed effects.

However, these, and other, coordinated and focused laboratory tests are designed to document the effects of the chemical using a continuous, controlled laboratory exposure that does not realistically reflect the likely patchy exposures typical of the District field application scenarios. As such, the toxicity information generated using laboratory tests (and some limited field tests) are intended as an overview of potential issues that might be associated with maximum direct exposures to develop and recommend guidance for use that should provide maximum exposure levels of applications that are protective of ecological health. These guidelines include numerous “safety margins” in the toxicity calculations that are intended to provide adequate efficacy to target organisms while not adversely impacting humans or nontarget plant and animal species. In some instances, the regulatory guidance may include additional suggestions for protective application to assure no significant adverse effect on nontarget species and humans.

The regulatory community uses this basic information to provide a relative comparison of the potential for a chemical to result in unwanted adverse effects and this information is reflected in the approved usage labels and material safety data sheets (MSDSs)[4], in actual practice, the amounts actually applied by the District within the District's Program Area for vector control are often substantially less than the amounts used in the laboratory toxicity studies. Because of the large safety factors used to develop recommended product label application rates, the amount of chemical resulting in demonstrated toxicity in the laboratory is much higher than the low exposure levels associated with an actual application for vector control. The application concentrations consistent with the labels or MSDSs are designed to be protective of the health of humans and other nontarget species (i.e., low enough to not kill them, weaken them, or cause them to fail to reproduce). Impacts may occur to some nontarget organisms. Although numerous precautions (BMPs) and use of recommended application guidance is intended to provide efficacy without adverse effects to nontarget organisms, misapplication or unexpected weather conditions may still result in effects on some nontarget organisms in the exposure area. This potential impact is ameliorated/mitigated by careful use of BMPs and advance planning by the District.

Although laboratory toxicity testing focuses on tiered concentrations of chemical exposure, the results of these tests produce a series of toxicity estimates of concentrations less than those that produce mortality. Extrapolation of these data is used to generate estimates of chronic toxicity or possible effects of lower doses that may result in sublethal effects such as reproduction or metabolic changes. In reality, these low-dose exposures need to be sustained over longer periods than are relevant to typical application scenarios for vector control including multiple applications in an area such as a wetland.

4.2.2.5 Chemistry, Fate, and Transport

The toxicity of a chemical is also affected by various biological, chemical, and physical parameters that affect the behavior of a compound in the environment and its potential toxicity. The chemistry, fate, and transport of a compound must be analyzed to fully estimate potential exposure to a given receptor. The fate and transport of a compound is determined by the physical and chemical properties of the compound itself and the environment in which it is released. Thus, the following characteristics of a compound must be evaluated: its half-life in various environmental media (e.g., sediment, water, air); photolytic half-life; lipid and water solubility; adsorption to sediments and plants; and volatilization. Environmental factors that affect fate and transport processes include temperature, rainfall, wind, sunlight, water turbidity, dissolved oxygen concentrations, and water and soil pH. Information pertaining to these parameters allows evaluation of how compounds may be transported between environmental media (e.g., from sediments to biota), how a compound may be degraded into various breakdown products, and how long a compound or its breakdown products may persist in different environmental media. In general, when a compound or its breakdown products decomposes rapidly in the environment and does not persist for extended periods, then the compound or product poses a lower risk to nontarget species and a lower potential for environmental pollution. Appendix B provides a discussion of the environmental fate of the pesticide active ingredients and other chemicals associated with specific pesticide formulations used in the Vegetation Management and Chemical Control alternatives.

[4] Although the MSDS format is referenced in this document, it should be noted that under the international Globally Harmonized System, the MSDS format has been substantially revised and is now largely replaced by standardized Safety Data Sheets (SDSs).

4.2.2.6 Ecological Food Web

While it is important to evaluate the potential adverse impacts of a pesticide application to potentially affected nontarget species, it is not practical to evaluate those potential impacts to all of the food webs present in the various ecosystems under consideration. An ecological food web is represented in the illustration representing some of the multitude of possible biotic and food uptake interactions in an ecosystem. Figure 4-2 depicts a highly simplified food web. In an ecological system each level in the food web is occupied by dozens or hundreds of species, with consumers using those resources (in this case species from a lower trophic level) in different ways depending on availability and competition for those resources. Their utilization of these resources shifts by time of day and season, and multiple resources being used simultaneously or alternatively. If the availability of one resource deceases, the consumer can generally replace that with another resource. Each of the possible connections between species is also associated with other interactions, such as competitive release, where the abundance of a species increases in response to the decline in a competitor's abundance, or competitive interactions between consumers where one consumer can use a particular resource better than its competitor.

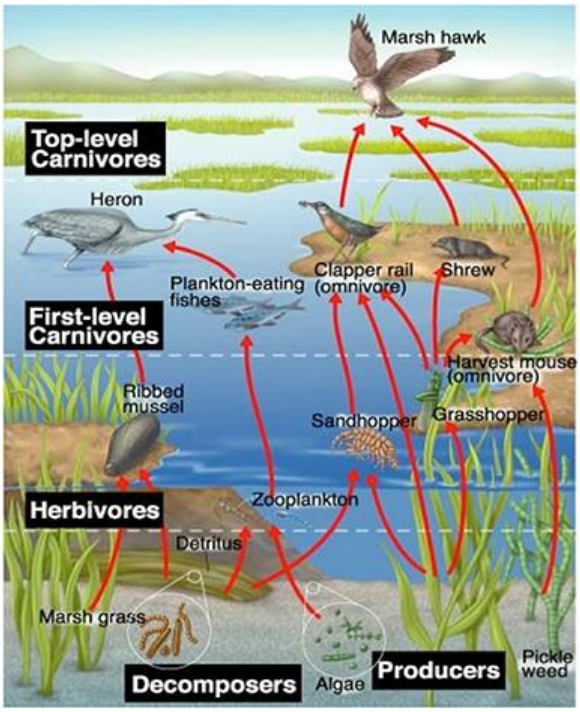


Figure 4-2 Ecological Food Web Concept

Although ecological food webs could be used to describe the complex system interactions that might be associated with District pesticide application scenarios, it is neither feasible nor practical to evaluate those potential impacts using a food-web approach. The numerous, interactions in typical food webs are highly complex and would be subject to substantial uncertainty, making it exceedingly difficult to confidently assess relevant impacts. Because of these constraints and complexity, it is neither practical nor productive to attempt to predict food-web interactions for each of the numerous application scenarios the District uses. It is appropriate, however, to use a food-web analysis to identify and consider the first level of potentially adverse effects to nontarget species that might result from a pesticide application. This information is used to assure a minimal impact to nontarget species and is typically a part of the MSDS and Toxicology profiles, providing the basis for the more reasonable, technically feasible approach to consider the possible nontarget impacts prior to use and the compatibility of each proposed pesticide in the overall approach to the typical vector control chemical application by the District.

Pesticides can kill natural predators of mosquitoes. The District's activities associated with the Physical Control and Vegetation Management Alternatives would help allow these predators to access habitats where mosquito larvae are present. When chemical control is used to manage mosquitoes it generally is used at levels that are below the effects thresholds for other insects and invertebrate predators, as described above. Although mosquito pesticides may also affect invertebrate predators (e.g., dragonflies), recovery of predator populations is usually rapid as the predator populations extend beyond the application areas and will rapidly replace any lost individuals. In general, the pesticides used for mosquito control exhibit low or no toxicity to birds or mammals. Limited information is available regarding toxic effects to reptile or terrestrial amphibian mosquito predators.

Mosquitoes are part of the food web and their loss may reduce the food base for some predators. Although mosquitoes serve a role as one of many types of prey items for some fish, avian insectivores, bats, and small reptiles and amphibians, the reduction of mosquito abundance over a small area will not affect the predator populations overall, as other prey sources are available.

4.2.3 Surveillance Alternative

Surveillance activities involve monitoring the abundance of adult and larval mosquitoes, field inspection of mosquito habitat, testing for the presence of antibodies specific to encephalitis virus in domestic and wild fowl, collection and testing of ticks, small rodent trapping and disease testing, and/or response to public service requests regarding vectors such as mosquitoes and yellow jackets.

Mosquito populations are monitored through the use of traps, inspections, and sampling in mosquito habitats. Known and suspected habitats are anywhere that water can collect, be stored, or remain standing for more than a few days, including, but not limited to, catch basins, stormwater detention systems, residential communities, parks, ornamental ponds, unmaintained swimming pools, seeps, seasonal wetlands, tidal and diked marshes, wastewater ponds, sewer plants, winery waste/agricultural ponds, managed waterfowl ponds, canals, creeks, treeholes, and flooded basements. If preexisting roads and trails are not available, low ground pressure ATVs may be used to access sites. Offroad access is minimized and used only when roads and trails are not available. Ticks are collected along trails and sampled for disease. Rodents (roof rats and Norway rats) may be collected during inspections to respond to public service requests.

4.2.3.1 Impacts to Special-Status Species

The Surveillance Alternative would affect small areas with the intent of monitoring vector populations to determine where control alternatives are required. Small numbers of vector and nontarget organisms are trapped at sites with the potential to support substantial vector populations. These sites are dispersed throughout the District. Chemicals may be used within adult mosquito traps (some adult mosquito traps use a Vapona strip infused with dichlorvos), but these chemicals are confined to the traps and do not enter the environment. Surveillance activities would occur in all wetland and aquatic habitat types, except open water and tidal flats (see Table 4-2 in Section 4.1.1). Surveillance activities would be conducted in accordance with the BMPs relating to agency communication, pre-treatment screening, environmental training, and disturbance minimization as detailed in Table 4-6. The potential impacts of the Surveillance Alternative would be similar for all habitat types, although the species potentially affected would differ, as indicated in Tables 4-3 and 4-4.

Small impacts to upland and wetland habitats in the vicinity of aquatic ecosystems may occur when the District is required to maintain paths and clearings to access surveillance sites and facilitate sampling. Such maintenance may include clearing small amounts of vegetation to retain footpaths up to 3 feet wide, or ATV/ARGO paths up to 6 feet wide. However, the vast majority of access routes are via preexisting roads, trails, and walkways, and do not require clearing by the District. Some trails do require periodic clearing by the District. Occasionally new access routes may be required to assess a vector source. This will often consist of personnel picking their way through natural openings in the vegetation to the source, but in some cases (i.e., heavy growth of blackberries or poison oak) a trail may need to be created. Where such clearing is required, it is generally done with hand tools. In those rare cases where especially dense vegetation is encountered, a skip loader with mower attachment may be used. No trimming of vegetation greater than 4 inches diameter breast height would be conducted. Most heavier trail maintenance activities, especially those using weed trimmers, small chainsaws, or other motorized equipment, would be conducted in the fall, when potential impacts associated with disturbance of breeding habitat would be minimized. However, lighter trail maintenance activities (trimming back small branches or fronds hanging over the access route) may occasionally occur during other times of year. These activities are of small size, and new access routes would be minimal; therefore, indirect impacts to wetland and aquatic habitats would be inconsequential.

The presence of District personnel and equipment implementing the Surveillance Alternative and associated noise could result in disturbance to special-status aquatic species. Such disturbance is most likely to occur during breeding season for fish and amphibians, should the animals abandon suitable habitat as a result of such disturbance. These disturbances would be very minor and of short duration, so would likely not cause these animals to abandon the area, but rather move away from the activity while it is occurring. Special-status invertebrates (all species associated with vernal pools, with the exception of the California freshwater shrimp) would likely not be disturbed by the presence of District personnel.

The Surveillance Alternative may also result in disturbance to species as District personnel are traveling to and from surveillance sites. These access-related impacts would be minimized by adherence to the BMPs previously cited, but in particular discussing activities regularly with regulatory agencies or wildlife refuge managers, staying on existing access routes wherever possible, maintaining and implementing training from USFWS and CDFW personnel regarding special-status species, and being aware of the environment and minimizing noise and disturbance when working in the field.

In addition, when working in tidal marshes, the District will implement all Tidal Marsh-Specific BMPs, as well as those for salt marsh harvest mouse, Ridgway's rail and soft bird's beak, where these species are potentially present, as determined through discussion with refuge managers, CDFW, or USFWS personnel. This will include continuing to follow the measures provided in the USFWS' "Walking in the Marsh;" employing seasonal and daily activity restriction periods, wherever practical; minimizing travel along tidal channels and sloughs; limiting vegetation removal to the minimum necessary; and other BMPs as indicated in Table 4-6. Through the implementation of these BMPs, substantive impacts to habitat would be avoided and no impact to special-status animals would occur.

The only potential for the Surveillance Alternative to directly impact fish, amphibians or special-status aquatic invertebrates would be when dipping to collect samples. Prior to collection of a sample, the technician would visually inspect the area to be sampled for nontarget organisms and avoid areas where special-status species were potentially present. Samples consist of collection of approximately 1 pint of water from the immediate surface of the waterbody, where mosquito larvae live, an area special-status fish and invertebrates are unlikely to occupy, as their risk of predation is increased in these areas. The sample would be inspected for vertebrates or special-status invertebrates, and in the unlikely event that such are captured, these animals would be returned immediately to the source water. It is highly unlikely that the organism would be harmed.

Surveillance activities might result in some physical damage to habitat or associated vegetation from foot traffic in areas without marked trails to access areas for potential vector inspection. Special-status species could be directly impacted by these activities. The District investigates sites for the presence of special-status species prior to initiating any further surveillance measures in natural habitat areas, and only small areas would be disrupted briefly by access activities. As explained above, most surveillance occurs along access routes that are already established, and would only be cleared periodically to maintain access, as necessary. Where new access routes are required they would have only a very small effect on habitat in areas where surveillance occurs. Therefore, minimal impacts would occur to aquatic species.

> **Impact AR-1.** The Surveillance Alternative would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.

4.2.3.2 Impacts to Habitat

This alternative would not affect the quantity or distribution of habitats, such as riparian areas, marshes, lakes or ponds, seasonal wetlands, or other habitat types identified as sensitive natural communities in local or regional plans, policies, regulations, or by the CDFW or USFWS. This alternative would not affect the composition of their vegetative communities, as very limited numbers of plants would be pruned or removed over a very small area. Surveillance would not result in any ground-disturbing activity and, therefore, would not result in any removal, filling or hydrologic interruption of federally protected wetlands as defined by Section 404 of the Clean Water Act, (including but not limited to, marsh, vernal pool, coastal, etc.). Most surveillance occurs along access routes that are already established, and would only be cleared periodically, during the fall to minimize impacts, to maintain access, as necessary. Where new access routes are required they would have only a very small effect on habitat in areas where surveillance occurs.

The District has long-standing cooperative and collaborative relationships with CDFW, professional biologists and property owners with regard to access, mosquito surveillance and control in association with vernal pools. District staff have received information and training from CDFW and professional biologists with respect to minimizing the potential for impacts to vernal pool habitat and specifically California tiger salamander, Sebastopol meadowfoam, Burke's goldfields, and Sonoma sunshine. When using ATVs to perform mosquito surveillance in the proximity of vernal pools, District staff stay outside of the margin of the vernal pools (delineated by the change from wetland to upland vegetation types), and do not operate ATVs within the actual vernal pool. The District may cross hydrological connections, i.e., swales, between vernal pools when necessary and with permission from regulatory agencies. When possible, District staff performs mosquito surveillance on foot with hand equipment, or by operating ATVs in upland areas a considerable distance from the pools and walking from the ATV to the pools to perform mosquito control (e.g., using a long hose reel based on the ATV). When it is necessary to use an ATV for mosquito surveillance in proximity to vernal pools, the District utilizes low ground pressure vehicles. District staff operates ATVs at slow speeds on sites containing vernal pools, and remains observant while operating equipment and walking in and amongst vernal pool habitat. The District avoids performing mosquito surveillance on rainy days or during dawn and dusk to avoid peak movement periods for California tiger salamander.

> **Impact AR-2.** The Surveillance Alternative would have a **less-than-significant** impact on any riparian habitat or other sensitive natural community No mitigation is required.
>
> **Impact AR-3.** The Surveillance Alternative would have a **less-than-significant** impact on federally protected wetlands as defined by Section 404 of the Clean Water Act. No mitigation is required.

4.2.3.3 Impacts to Migration and Movement

Any disruption of migration patterns would be due to the presence of personnel and machinery in the environment. In all cases this would be a very short-term occurrence, generally not more than a few hours in any given location and, therefore, this effect would be minimal and would have no effect on the movement of wildlife and would not affect wildlife migration corridors or nursery areas, as no physical disturbance would occur.

> **Impact AR-4.** The Surveillance Alternative would have **no impact** on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites.

4.2.3.4 Conflict with Local Ordinances

The county and city general plans and their goals and policies pertaining to natural resources are protective of aquatic resources and focused on conservation of existing resources including riparian, wetland, and bayland communities. Surveillance activities would not result in the conversion of natural habitats to other land uses or in the long-term or permanent dislocation of plant and animal species from natural areas except indirectly for mosquitoes and vectors of disease and discomfort. Surveillance activities would not affect trees more than 4 inches diameter at breast height and, therefore, would not conflict with local tree ordinances.

> **Impact AR-5.** The Surveillance Alternative would have **no impact** on local policies or ordinances protecting biological resources.

4.2.3.5 Conflict with Conservation Plans

Two conservation plans, Turkey Road and the SRPCS, were identified whose action area is within the District's primary Service Area. The Turkey Road HCP provides for protection and mitigation of impacts to California red-legged frog associated with residential and vineyard development. The SRPCS provides for the protection and mitigation of impacts to California tiger salamander and four listed plant species from development on the Santa Rosa Plain.

The District conducts surveillance operations within the area covered by the regional SRPCS. While District activities may occur within the boundaries of conservation areas, these activities are coordinated with the plan managers. The District regularly communicates with and works collaboratively with the SRPCS Interagency Review Team (IRT, also referred to as the Implementation Committee) and representatives from agencies such as RWQCB, USEPA, USACE, CDFW, and USFWS. The District receives training from agency staff and independent biologists (e.g., CDFW, USACE) to minimize impacts and conducts annual field training for field staff regarding precautionary and avoidance measures related to vernal pool habitat. The District uses specialized equipment in conjunction with vernal pool habitats.

Six conservation plans affect portions of adjacent counties as identified in Table 4-5. District activities are typically not among those covered by these HCPs. When called into these adjacent counties to perform work, the District would operate under the auspices of that county's mosquito and vector control district and in compliance with their practices and permits, or with the county, if there is no vector control district. The District would operate in compliance with all active HCP/NCCPs. Therefore, the District activities would not be in conflict with the provisions of any adopted HCP, NCCP, or other approved local, regional, or state-approved conservation plan.

> **Impact AR-6**. The Surveillance Alternative has a **less-than-significant** impact on any adopted HCPs or NCCPs. No mitigation is required.

4.2.4 Physical Control Alternative

The Physical Control Alternative would be a continuation of existing activities using applicable techniques, equipment, vehicles, and watercraft.

Physical control for mosquitoes consists of the management of aquatic areas that provide mosquito-producing habitat (including freshwater marshes and lakes, saltwater marshes, temporary standing water, vernal pools, and wastewater treatment facilities) especially through water control and maintenance or improvement of channels, tide gates, levees, and other water control facilities. For physical control measures used for onsite wastewater treatment systems, see Section 9.2.4.

The potential effects of this alternative on these habitats are described below. The District may also advise landowners and homeowners about the importance of dumping/inverting of containers holding water, controlling vegetation against structures, and avoiding stagnant ponds. In situations where any potential

exists for sensitive habitats or special-status species to be present, the District includes information and contact data for resource agencies and potential permits.

4.2.4.1 Impacts to Special-Status Species and Habitats

Mosquitoes typically breed in shallow areas, with emergent vegetation, little to no current, and where fish are excluded. This alternative modifies habitats that support mosquito larva to make these habitats less suitable for mosquitoes and/or more suitable for their predators. This alternative includes maintenance of ditches and water control structures, removal of debris and weeds, clearance of brush for access to areas to be treated, and filling of nonfunctional water circulation ditches. It may also include reconnecting backwaters or isolated pools on the floodplains of streams and rivers, and increased drainage rates and areas in managed wetlands. These activities are conducted in accordance with all appropriate environmental regulations. This work in creeks, rivers, ponds, lakes, marshes and other wetlands may require permits from the USACE, RWQCB, CDFW, USFWS, NOAA Fisheries, and others. Federally protected wetlands are defined by Section 404 of the Clean Water Act, (including but not limited to, marsh, vernal pool, coastal, etc.) where adverse effects could occur through direct removal, filling, hydrological interruption, or other means. The Physical Control Alternative would not reduce the quantity of this habitat, but simply improve circulation within the marsh. Only inactive channels would be filled to eliminate ponding. Work would not begin until all required permits are obtained. The District may also advise landowners and homeowners about the importance of dumping/inverting of containers holding water, controlling vegetation against structures. In situations where there is any potential for sensitive habitats or species to be present, the District includes information and contact data for resource agencies and potential permits.

District activities largely involve maintenance of existing facilities in the same manner they do under baseline conditions. The District is rarely involved in new drainage projects, and when they are, they consult with the appropriate agencies and acquire all required permits for implementing that work, which provides protection for native and special-status fish species. The District's annual work plans are submitted for review by other responsible agencies prior to implementation. Completed work is available for inspection by the USACE, USFWS, and CDFW upon request.

Physical control activities occur in most aquatic and wetland habitats, with the exception of open water and tidal flat habitats, as these do not provide suitable habitat for mosquitoes, due to their circulation patterns. Impacts are evaluated based on the types and locations of habitats where such activities would be performed. Impact determinations of significance follow the analyses by habitat type. These activities would generally occur over a period of a few days in any specific location, and so the physical disturbance would be very short term. The impacts could include short-term increases in dust and sedimentation, but BMPs (see category G in Table 4-6) would be implemented to make these impacts less than significant. Short-term increases in noise could also result. This would be expected to have the largest effect on adult amphibians when they are out of the water, or terrestrial animals. Most of this work will be conducted when the area is dry or otherwise isolated from active waterways, so impacts to purely aquatic organisms from noise and vibration are not expected to occur.

Mosquitoes are part of the food web and their loss may reduce the food base for some predators. Although mosquitoes serve a role as one of many types of prey items for some fish, avian insectivores, bats, and small reptiles and amphibians, the reduction of mosquito abundance over a small area will not affect the predator populations overall, as other prey sources are available.

Physical control measures for rodents and other nuisance wildlife would be limited to providing advice for restricting ingress of rodents into structures or decreasing habitat for them near residences. These measures would not affect aquatic habitats and would have no effect on aquatic resources. Physical controls are not implemented for yellow jackets or ticks.

4.2.4.1.1 Creeks and Rivers and Riparian Corridors

Because their rapid currents do not provide suitable habitat for mosquitoes, creeks and rivers generally do not support substantial numbers of mosquitoes, although, some mosquitoes can be found in slow eddies and back channels, or in pools isolated on the banks as flows recede. Creeks and rivers may support special-status fish species including steelhead, Chinook salmon, foothill yellow legged frog, California red legged frog, California freshwater shrimp, and other species, as indicated in Table 4-1. Isolated ponds and back channels may provide habitat for mosquito larva, but these areas may also provide excellent rearing habitat for young fish and amphibians, as they provide warmer water temperatures, higher primary productivity and protection from predaceous fish. Draining areas of shallow freshwater habitat to reduce the amount of standing water or reduce the amount of time such water remains standing could result in adverse effects to young fish or amphibians using those habitats, leaving organisms that cannot vacate the area without water, or requiring organisms that can leave the area to move to new locations, and reducing the amount of larval rearing habitat present. Where native or special-status fish species are not present, these impacts would be negligible. Where native or special-status species are present, these areas could be important nursery areas, depending on location, season, species present, and amount of other habitat available to the species. Habitat alterations to drain such areas will be avoided to the maximum extent possible. This type of activity is not routinely conducted by the District, but may be required in some circumstances. The potential effects of this alternative would be avoided or minimized through implementation of the BMPs in Table 4-6, including those relating to agency communication, environmental training, and pre-treatment screening (see BMP A7). The habitat and species-specific BMPs in Table 4-6 may also be applied, including seasonal avoidance measures. Furthermore, BMP G3 requires that all maintenance work will be done at times that minimize adverse impacts to nesting birds, anadromous fish, and other species of concern, in consultation with USFWS, NMFS, and CDFW. With these BMPs, the effects of this alternative would be less than significant.

4.2.4.1.2 Ponds and Lakes

The freshwater habitats that could be treated include the margin of reservoirs and ponds (including artificial ponds such as golf course ponds or stock ponds with natural bottoms). These areas are generally man-made habitats, and if they support fish, these fish will largely consist of introduced species, or stocked native species such as rainbow trout. While rainbow trout are native to the region, these stocked fish are not considered to be natural populations, and are treated as introduced fish. Amphibians (i.e., red legged-frog, California tiger salamander) or western pond turtles may also use these reservoirs and ponds, particularly if these areas do not support fish.

Treatment of stagnant areas where mosquito larvae eggs and larvae occur would be accomplished by increasing circulation (water flow) to these areas. This increases the accessibility of these areas to young fish, which then eat the mosquito larvae. This access provides these fish with a previously inaccessible food source. Additionally, these areas can be important for young fish, as they provide protection from predation by larger fish and tend to be warmer, with higher primary productivity, providing good conditions for the growth of young fish. Most young fish eat insect larvae during at least the first few months of their lives, and some species eat insect larvae throughout their lives. Special-status fish species would not be impacted in reservoirs and ponds, and ditches, as these species do not occur in these habitats.

This type of treatment could affect breeding and rearing areas for amphibians, as they tend to avoid areas where fish are present. This would increase the risk of predation on eggs and tadpoles. This potential effect would be avoided and minimized by the BMPs in Table 4-6 relating to agency communication, environmental training, and pre-treatment screening. The habitat and species-specific BMPs in Table 4-6 may also be applied, including seasonal avoidance measures. Furthermore, BMP G3 requires that all maintenance work will be done at times that minimize adverse impacts to nesting birds, anadromous fish, and other species of concern, in consultation with USFWS, NMFS, and CDFW. With these BMPs, the effects of this alternative would be less than significant.

4.2.4.1.3 Freshwater Marsh/Seeps

Freshwater marsh and seeps may provide ideal habitat for mosquito breeding due to their substantial areas of shallow water, limited circulation and emergent vegetation. These areas may potentially support a number of native and nonnative fish, amphibians (California tiger salamander) and reptiles (western pond turtle), as indicated in Table 4-1. Physical control in these areas would have the same potential effects as described for lake and pond habitats and would be avoided or minimized by the BMPs in Table 4-6 relating to agency communication, environmental training, and pre-treatment screening. The habitat and species-specific BMPs may also be applied, including seasonal avoidance measures. Furthermore, BMP G3 requires that all maintenance work will be done at times that minimize adverse impacts to nesting birds, anadromous fish, and other species of concern, in consultation with USFWS, NMFS, and CDFW. With these BMPs, the effects of this action would be less than significant.

4.2.4.1.4 Seasonal Wetlands (includes Vernal Pools)

The USACE defines wetlands as "*those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. (33 [Code of Federal Regulations] CFR 328.3(b); 40 CFR 230.3(t)).*" For the purposes of this document, seasonal wetlands are areas that are flooded for 1 week or more during the year, generally during the rainy season, but do not retain water through the entire year. Seasonal wetlands may be flooded by increased runoff, rainfall, or unusually high tides. Fish may use these areas for spawning and rearing. Splittail, for instance, use floodplain habitats to spawn and rear (Moyle 2002). Their young may live in these seasonally flooded habitats for several weeks, until these habitats dry out. Chinook salmon can use flooded wetlands and floodplains for rearing habitat during their outward migration toward the ocean. Young salmonids using these seasonally flooded wetlands have higher growth rates than the fish that remain in the mainstem rivers (Sommer et al. 2003; Swenson et al. 2003; Moyle et al. 2007). The availability of such habitats has been substantially reduced by human land use practices and flood control measures. Reducing the frequency or duration with which such habitats are flooded would adversely affect habitat and aquatic resources. The Physical Control Alternative would not reduce the quantity of this habitat, but simply improve circulation within the marsh. Only inactive channels would be filled to eliminate ponding. All work in wetlands would be subject to additional permitting by the USACE, CDFW, BCDC, and RWQCB.

Vernal pools[5], a specific type of seasonal wetland, sometimes support a unique assemblage of endemic plant and animal species, many of which have been identified as special-status species by federal and state agencies (see Table 4-1). The District receives environmental awareness training from agency staff (e.g., CDFW, USACE) and independent biologists to minimize impacts and conducts annual field training for field staff regarding precautionary and avoidance measures related to vernal pool habitat. This training addresses California tiger salamander, Sebastopol meadowfoam, Burke's goldfields, and Sonoma sunshine. When using ATVs to perform mosquito control in the proximity of vernal pools, District staff stay outside of the margin of the vernal pools (delineated by vegetation change from wetland to upland), and do not operate ATVs within the actual vernal pool. The District may cross hydrological connections, i.e., swales, between vernal pools when necessary and with permission from regulatory agencies. When possible, District staff performs mosquito control on foot with hand equipment, or by operating ATVs in upland areas a considerable distance from the pools and walking from the ATV to the pools to perform mosquito control (e.g., using a long hose reel based on the ATV). When it is necessary to use an ATV for mosquito control in proximity to vernal pools, the District utilizes low ground pressure vehicles. District staff operates ATVs at slow speeds on sites containing vernal pools and remains observant while

[5] ''Vernal pool,'' whether by transfer or by independent invention, is now applied to small wetlands that are present primarily or exclusively in the early part of the growing season and that typically ''dry'' completely or ''substantially'' at some point during the growing season. (http://users.ipfw.edu/isiorho/wetvernalisolatedwetlands2003.pdf)

operating equipment and walking in and amongst vernal pool habitat. The District avoids performing mosquito control on rainy days or during dawn and dusk to avoid peak movement periods for California tiger salamander.

The District conducts physical control operations within the area covered by the regional Santa Rosa Plains Conservation Strategy. The District regularly communicates with and works collaboratively with the SRPCS IRT and representatives from agencies such as RWQCB, USEPA, USACE, CDFW, and USFWS.

Because of the sensitive nature of these habitat types, the District generally would not undertake Physical Control measures in these areas. In the event that Physical Control in a vernal pool was required, the District would not implement such actions without previously discussing their need with the relevant regulatory agencies to verify that no other option exists to control the mosquito problem and to make sure that any such activity would be done in such a way as to minimize its impacts. As a result, this "consultation prior to implementation" BMP and the practices described above will result in a less-than-significant impact to seasonal wetland resources.

4.2.4.1.5 Lagoon

Lagoons, located at the mouths of creeks or rivers where they enter the ocean or bay, but isolated from the receiving waterbody by a berm, are indirectly influenced by the tide, which may cause freshwater to back up within the lagoon, and may also allow water to percolate through the berm, with the direction of such movement depending on water levels on either side of the berm. As a result, lagoons often contain a lens of freshwater at the surface and brackish water at the bottom. Lagoons may therefore contain species from both creeks and rivers, and from the receiving waterbodies. Amphibians are not likely to occur in lagoons due to elevated salt content, but could occur at the upstream end of the lagoon, within the backwater, but above the reach of the saline influence. Lagoons would support mosquitoes in areas of reduced circulation, often associated with emergent vegetation. Physical control in lagoons would include reconnecting isolated areas to the main lagoon. The BMPs in Table 4-6 would be applied to avoid or minimize impacts to environmental resources. BMP G3 requires that all maintenance work will be done at times that minimize adverse impacts to nesting birds, anadromous fish, and other species of concern, in consultation with USFWS, NMFS, and CDFW. With these BMPs, the effects of the Physical Control Alternative on resources within the lagoon would be less than significant.

4.2.4.1.6 Tidal Marsh and Channels

Tidal marsh and tidal channel habitats occur along the margins of San Francisco, San Pablo, and Suisun bays and are subject to tidal action.

They are typically bounded by levees and water control structures. The San Francisco Bay-Delta once supported vast tracts of freshwater, brackish, and saline marsh habitat. The vast majority of these marsh habitats have been converted to human uses such as farming, industrial uses, and urban development. Some of the remaining marsh lands are maintained and operated to provide habitat for wildlife or as private or public duck clubs. Several examples of these types of habitats occur along the Highway 37 corridor and along Highways 101 and 29 in close proximity to the cities of American Canyon, Napa, Sonoma, Petaluma, and Novato. These wetlands can be important sources of mosquitoes seasonally. These marshes are seasonally flooded and drained to optimize habitat for ducks, geese, and other wildlife. A variety of special-status fish species including all races of Central Valley Chinook salmon, steelhead, green sturgeon, delta smelt, longfin smelt, Sacramento splittail, and Sacramento perch could use these marshes. These tidal marshes, however, do not provide primary habitat for these species. No special-status amphibians, aquatic reptiles, or invertebrates occupy these habitats.

Physical measures to control mosquitoes in these areas include maintenance of ditches and water control structures, removal of debris and weeds, clearance of brush for access to areas to be treated, and filling of nonfunctional water circulation ditches, as described in Chapter 2. Other measures include retaining water on the surface of the area, and rotational impoundment monitoring, which reduces mosquito populations by

increasing the frequency with which suitable habitats are inundated and drained. The District works with landowners and property managers to accomplish these actions on an as needed basis. The District advises the landowner and property managers that these actions may require discussion with CDFW, NOAA Fisheries, or the USFWS and that these agencies should be contacted before work is initiated.

These activities would be subject to the BMPs described in Table 4-6, relating to agency communication, environmental training, and pre-treatment screening, and the tidal marsh-specific BMPs would also be employed including conducting this work during appropriate seasons and times of day (when the tide is out and when Ridgway's rail and salt marsh harvest mouse are not nesting), making sure staff have appropriate training when working in the marsh, minimizing the use of mechanical equipment where practical. Channels that have substantial tidal flow and inundation would not support mosquitoes and thus would not need to be maintained. Fish would be absent from the channels where maintenance is required during low tides, when the work would be conducted. Thus, fish would not be directly affected. Increasing circulation of water in low lying areas these areas would not substantially affect fish populations. Improving drainage of low-lying areas within these managed areas, which would be drained with or without mosquito control activities, could decrease the likelihood that fish become trapped or stranded. Construction of channels could result in temporary increases in turbidity, which could adversely affect fish. BMPs to avoid discharge of unsuitable material and spoils would be implemented to control and localize this turbidity. They may include constructing new channels during periods when the marsh is dry or isolating areas where new channels are being constructed from the surrounding environment and other BMPs associated with the USACE 404 and other permits required for such work. These turbidity increases would be short term and temporary and, thus, would not substantially affect aquatic species.

4.2.4.1.7 Water and Wastewater Treatment Facilities

Wastewater treatment facilities do not provide habitat for native or special-status fish species, although such facilities may lie close to suitable habitats in streams or the San Francisco Bay Delta system and connectivity may exist between the facility and the natural environment that could allow aquatic resources to enter the facility. The extent to which these species may enter these facilities is unknown. Because of the limited number of such facilities and the very limited use of such facilities by fish, amphibian or aquatic reptiles, physical control measures are not anticipated to substantially affect these fish species.

Septic/onsite wastewater treatment systems and their associated leach fields do not provide habitat for native fish or special-status fish, amphibian, aquatic reptile or invertebrate species. This type of facility would only affect fish if they drained into a waterbody supporting fish, in which case the physical control measures for freshwater habitats would apply.

Winery waste ponds generally contain waste from grape pressings and washwater from cleaning winery equipment. These ponds generally do not provide suitable habitat for special-status species, as they are highly managed and often suffer from low water quality. In Marin County, the permitting of these ponds is controlled by the County Division of Environmental Health Services and in Sonoma County by the Permit and Resource Management Department. In both cases, the local permitting agency deals with flows of up to 10,000 gallons per day and with subsurface disposal only. If the daily flow exceeds this value or surface disposal is used, the RWQCB is the controlling agency. The District provides input relating to controlling mosquitos and other vectors associated with the ponds and winery operations. Physical control is not typically undertaken in winery waste ponds, although it is possible that this could be required under unusual circumstances. Because of the poor quality habitat provided and because physical control activities would rarely be conducted in these waste ponds, there is little likelihood of impacts to special-status species.

Flood control channels and ditches may support special-status species where they have standing water for sufficient periods of time and have suitable physical and vegetative structure. Physical management activities would be designed to reduce ponding of water within these areas. The application of the BMPs in

Table 4-6, particularly those pertaining to agency communication, pre-treatment screening, and environmental training, would avoid impacts to any special-status species that might occur in these habitats.

4.2.4.1.8 Artificial Containers, Temporary Standing Waters and Ornamental Ponds

Artificial containers do not provide habitat for fish or support populations of native or special-status fish, amphibians, aquatic reptiles, or invertebrates. Thus, physical control of artificial containers (ensuring that these containers do not hold water for a sufficient period to support mosquito larvae) would have no impact on these species or their habitat.

Temporary standing waters refers to water ponding on an upland habitat because of rainfall or irrigation. Ornamental ponds are small ponds with artificial bottoms. These habitats do not provide habitat for special-status aquatic species.

4.2.4.1.9 Impact Determinations for Special-Status Species and Habitats

Impact AR-7. The Physical Control Alternative, would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.

Impact AR-8. The Physical Control Alternative would have a **less-than-significant** impact on any riparian habitat or other sensitive natural community. No mitigation is required.

Impact AR-9. The Physical Control Alternative would have a **less-than-significant** impact on federally protected wetlands as defined by Section 404 of the Clean Water Act. No mitigation is required.

4.2.4.2 Effects on Movement and Migration

Physical changes in the habitat would have the potential to affect fish migration. However these changes would tend to enhance migration, opening routes, not closing them. This alternative would likely benefit the movement of fish and other aquatic species, as it would deepen channels and improve flow. This effect would occur within restricted areas and would not substantially alter migratory pathways or success. Additional disruption of migration patterns may occur due to the presence of personnel and machinery in the environment. In all cases this would be a short-term occurrence, generally not more than a few days in any given location and, therefore, this effect would be minimal and would have little effect on the movement of fish and other aquatic species.

Impact AR-10. The Physical Control Alternative would have a **less-than-significant** impact on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites. No mitigation is required.

4.2.4.3 Conflict with Local Ordinances

The county and city general plans and their goals pertaining to natural resources are protective of terrestrial resources and focused on conservation of existing resources including mature trees and important woodland communities. Physical control activities would not result in the conversion of natural habitats to other land uses or in the long-term or permanent dislocation of plant and animal species from natural areas except for mosquitoes and vectors of disease and discomfort. The Physical Control Alternative would not affect trees more than 4 inches diameter breast height and, therefore, would not conflict with local tree ordinances.

Impact AR-11. The Physical Control Alternative would have **no impact** on local policies or ordinances protecting aquatic resources.

4.2.4.4 Conflict with Conservation Plans

Two conservation plans, Turkey Road and the SRPCS, were identified whose action area is within the District's primary Service Area. The Turkey Road HCP provides for protection and mitigation of impacts to California red-legged frog associated with residential and vineyard development. The SRPCS provides for the protection and mitigation of impacts to California tiger salamander and four listed plant species from development on the Santa Rosa Plain. While District activities may occur within the boundaries of conservation areas, these activities are coordinated with the plan managers and would not conflict with the provisions of any adopted HCP, NCCP, or other approved local, regional, or state habitat conservation plan.

The District's physical control work in the Santa Rosa Plain is infrequent and minimal. Work is not associated with vernal pools, rather the work is typically in conjunction with wastewater management irrigation (e.g., City of Santa Rosa) or with physical control in waste ponds (e.g., dairy). The District regularly communicates with and works collaboratively with the SRPCS IRT (also referred to as the Implementation Committee) and representatives from agencies such as RWQCB, USEPA, USACE, CDFW, and USFWS. The District receives training from agency staff and independent biologists (e.g., CDFW, USACE) to minimize impacts and conducts annual field training for field staff regarding precautionary and avoidance measures related to vernal pool habitat and other seasonal wetland and wetland habitats. The District uses specialized equipment in conjunction with vernal pool habitats, as previously described. While District activities may occur within the boundaries of conservation areas, these activities are coordinated with the plan managers and would not conflict with the provisions of any adopted HCP, NCCP, or other approved local, regional, or state habitat conservation plan.

Six conservation plans affect portions of adjacent counties. District activities are typically not among those covered by these HCPs. When called into these adjacent counties to perform work, the District would operate under the auspices of the affected county or that county's mosquito and vector control district and in compliance with their practices and permits, including compliance with all active HCP/NCCPs. Therefore, the District activities would not be in conflict with the provisions of any adopted HCP, NCCP, or other approved local, regional, or state-approved conservation plan.

> **Impact AR-12**. The Physical Control Alternative would have a **less-than-significant** impact on adopted HCPs or NCCPs. No mitigation is required.

4.2.5 Vegetation Management Alternative

The vegetation within and surrounding aquatic and wetland habitats is an important component of the aquatic ecosystem. This vegetation provides shade, helping to keep the water cool; increases structure and habitat complexity; and contributes organic material and insect drop, subsidizing the food web. It provides fish and other aquatic organisms with cover from aquatic and terrestrial predators and provides visual separation that increases the density of territorial species. Vegetation also helps slow runoff from the surrounding land surface, protecting the aquatic environment from sediments and toxins that may wash in from upland areas.

Vegetation management involves the trimming or removal of vegetation to improve access, and to improve water circulation to areas that support mosquito breeding and improve access to natural predators, so that chemical treatments are not required. All such work is done in coordination with the landowner or land manager and the resource agencies, as required. Permits are generally required for this type of activity, and this work would only be initiated after all necessary permits are obtained. All areas are pre-screened to determine the potential presence of special-status species and to develop appropriate measures to avoid or minimize effects to these species. The vast majority of this vegetation management work is conducted manually and encompasses only a small area. Occasionally, larger areas of vegetation may be removed using equipment, such as a skid steer with mower attachment. This equipment is typically used at a small number of sites to mow access paths in dense stands of cattails in seasonal wetlands and retention basins and infrequently in riparian habitat to mow access paths through dense stands of blackberry and poison oak

to facilitate surveillance and the application of larvicides. This work is typically done in the fall to avoid the breeding season for birds and other species. The District is in communication with resource agencies prior to performing this type of work. “Mechanized” vegetation management using equipment is typically restricted to ditches, wastewater ponds and stormwater retention basins or areas. The District will ensure that all required permits are in place before vegetation management activities are undertaken. Short-term (a few days to a week) increases in noise could result from the operation of heavy equipment under this alternative. This would be expected to have the largest effect on adult amphibians when they are out of the water (or terrestrial animals, discussed in Chapter 5), and would cause them to move away from the work area. Most of this work will be conducted when the area is dry or otherwise isolated from active waterways, so impacts to purely aquatic organisms from noise and vibration are not expected to occur.

The District preferentially uses physical control for vegetation management and rarely uses herbicides (and some adjuvants) for vegetation management in natural environments. The District may use herbicides in artificial environments, winery waste ponds, wastewater treatment ponds, and agricultural ditches. Whenever herbicides are used, they are applied in compliance with label requirements. As indicated in Table 4-7, a number of herbicides have low toxicity to fish and aquatic invertebrates. These herbicides would be used in areas near aquatic environments potentially supporting native or special-status aquatic species. Herbicides with moderate to high toxicity to fish and aquatic invertebrates would not be used in these areas (but may be used in less sensitive areas where needed). Toxicity information for these herbicides can be found in Appendix B and Chapter 6.

The District may use glyphosate on a limited, infrequent basis for mosquito source control. Although some recent concerns have been expressed about possible sublethal effects of glyphosate products (e.g., endocrine disruption in humans, see Section 7.2.5.1.), it is virtually nontoxic to mammals and practically nontoxic to birds, fish, and invertebrates on an acute basis. Claims that glyphosate is destroying bee and butterfly populations have not been substantiated. The use of glyphosate to control milkweed, which is a severe problem for farmers, may be connected to loss of foraging vegetation and, thereby, indirectly impacting butterfly populations. However, this effect is an indirect effect and not actually toxicity to the butterflies from glyphosate. With BMPs and targeted application techniques, glyphosate can be used safely when an adequate buffer (>15 feet) to water sources is maintained (glyphosate is much more toxic to fish and aquatic invertebrates than to mammals, birds, or terrestrial invertebrates) or when a formulation specifically designed for use in aquatic environments (Aquamaster) is used.

Table 4-7 Herbicide and Adjuvant Toxicity[1,2] to Fish and Aquatic Invertebrates

Chemical	Toxicity to	
	Fish	Aquatic Invertebrates
Imazapyr, glyphosate, modified plant oil and methylated seed oil, lecithin, aliphatic polycarboxylate	Low	Low
Triclopyr (triclopyr acid, TEA)	Moderate	Moderate
Triclopyr (TBEE), alkylphenol ethoxylates (APEs)	High	High

[1] Toxicity information is summarized from the information provided in Appendix B (Table 6-1) and Chapter 6.

[2] The toxicity data are derived from rigidly controlled laboratory animal studies designed to determine the potential adverse effects of the chemical under several possible routes of exposure (see Appendix B for further information). In these studies, the species of interest is continuously exposed to 100 percent chemical at several doses. In actual practice, the amounts applied in the District’s Program Area are substantially less than the amounts used in the toxicity studies, and organisms are not continuously exposed to the chemical. Furthermore, actual application rates by the District may be less than label maximum allowable application rates. Thus, the laboratory test results do not provide a realistic assessment of field exposure.

See Section 6.2.5 for further analysis of the herbicides and adjuvants that could be used on a limited basis for vegetation management. The herbicides the District would potentially use are discussed in detail in Appendix B and are listed in Table 2-1 with the active ingredients listed in Table 6-3. An adjuvant is any compound that is added to an herbicide (or pesticide) formulation or tank mix to facilitate the mixing, application, or effectiveness of that herbicide. Adjuvants can either enhance activity of an herbicide's active ingredient (activator adjuvant) or offset any problems associated with spray application, such as adverse water quality or wind (special purpose or utility modifiers). Activator adjuvants include surfactants, wetting agents, sticker-spreaders, and penetrants. The environmental fate and toxicity of adjuvants the District may use are described in detail in Appendix B and listed in Table 6-4.

4.2.5.1 Impacts to Special-Status Species and Habitats

The District would conduct vegetation management work infrequently in or adjacent to creeks, rivers, ponds, lakes, marshes, and other wetlands that may require permits from the USACE, RWQCB, CDFW, USFWS, NOAA Fisheries, and others. Work would not begin until all required permits are obtained. The potential effects of this alternative on these aquatic habitats are described below.

Mosquitoes are part of the food web and their loss may reduce the food base for some predators. Although mosquitoes serve a role as one of many types of prey items for some fish, avian insectivores, bats, and small reptiles and amphibians, the reduction of mosquito abundance over a small area will not affect the predator populations overall, as other prey sources are available.

4.2.5.1.1 Creeks and Rivers and Riparian Corridors

Because their rapid currents do not provide suitable habitat for mosquitoes, creeks and rivers generally do not support substantial numbers of mosquitoes, although, some mosquitoes can be found in slow eddies and back channels, or in pools isolated on the banks as flows recede. Creeks and rivers may support special-status species including steelhead, Chinook salmon, foothill yellow legged frog, California red legged frog, California freshwater shrimp, and other species, as indicated in Table 4-1. Isolated ponds and back channels may provide habitat for mosquito larva, but these areas may also provide excellent rearing habitat for young fish and amphibians, as they provide warmer water temperatures, higher primary productivity and protection from predaceous fish.

Vegetation that requires management would typically be confined to channel margins and backwaters with slow currents. This activity would be done in coordination with landowners or land managers and resource agencies, as well as following the BMPs described in Table 4-6 relating to environmental training, pre-treatment screening, disturbance minimization, habitat and species-specific BMPs, and vegetation management-specific BMPs. This would result in less-than-significant impacts to fish, amphibians, and aquatic reptiles associated with creeks and streams.

4.2.5.1.2 Ponds and Lakes

The freshwater habitats that could be treated include the margin of reservoirs and ponds (including artificial ponds such as golf course ponds or stock ponds with natural bottoms). These areas are generally man-made habitats, and if they support fish, these fish will largely consist of introduced species, or stocked native species such as rainbow trout. While rainbow trout are native to the region, these stocked fish are not considered to be natural populations, and are treated as introduced fish. Amphibians (i.e., red legged-frog, California tiger salamander) or western pond turtles may also use these reservoirs and ponds, particularly if these areas do not support fish.

Vegetation management would be limited in this habitat type, except in smaller ponds, as the depth and size of these areas would typically preclude emergent vegetation from exceeding 30 percent of the surface area. Where necessary, vegetation management activities would be implemented in stagnant areas along the edges of these habitats where mosquito larvae eggs and larvae occur. Special-status fish species would not be impacted in reservoirs and ponds, and ditches, as these species do not occur in

these habitats. Amphibians would likely not be present in lakes or ponds supporting fish, but may be present in some areas. Vegetation management could reduce cover for these species and increase their vulnerability to predation, but substantial areas of similar habitat would remain.

This potential effect would be avoided and minimized by the BMPs in Table 4-6 relating to agency communication, environmental training, and pre-treatment screening. Vegetation management -specific BMPs would be applied. The species-specific BMPs in Table 4-6 may also be applied, including seasonal avoidance measures. With these BMPs, the effects of vegetation control activities would be less than significant.

4.2.5.1.3 Freshwater Marsh/Seeps

Freshwater marsh and seeps may provide ideal habitat for mosquito breeding due to their substantial areas of shallow water, limited circulation and emergent vegetation. These areas may potentially support a number of native and nonnative fish, amphibians (California tiger salamander) and reptiles (western pond turtle), as indicated in Table 4-1. Vegetation management in these areas would have the same potential effects as described for lake and pond habitats and would be avoided or minimized by the BMPs in Table 4-6 relating to agency communication, environmental training, and pre-treatment screening. The vegetation management and species-specific BMPs in Table 4-6 may also be applied, including seasonal avoidance measures. With these BMPs, the effects of this activity would be less than significant.

4.2.5.1.4 Seasonal Wetlands (includes Vernal Pools)

Seasonal wetlands, including vernal pools, may also support substantial stands of emergent vegetation, although these areas are typically not inundated for long enough periods to support dense stands of vegetation preferred by mosquitoes. As a result, these areas are unlikely to be subject to vegetation management actions. While the District would not operate equipment including ATVs within vernal pools, the District may cross hydrological connections, i.e., swales, between vernal pools when necessary and with permission from regulatory agencies. If vegetation management activities were required, potential effects would be avoided and minimized by the BMPs in Table 4-6 relating to agency communication, environmental training, and pre-treatment screening.

The District conducts limited control operations within the area covered by the regional Santa Rosa Plains Conservation Strategy. The District regularly communicates with and works collaboratively with the SRPCS IRT and representatives from agencies such as RWQCB, USEPA, USACE, CDFW, and USFWS. The District receives training from agency staff and independent biologists (e.g., CDFW, USACE) to minimize impacts and conducts annual field training for field staff regarding precautionary and avoidance measures related to vernal pool habitat. The District uses specialized equipment in conjunction with vernal pool habitats.

From Table 4-6, the vegetation management-specific BMPs would be applied. The species-specific BMPs may also be applied, including seasonal avoidance measures. With these BMPs, the effects of this action would be less-than-significant.

4.2.5.1.5 Lagoon

Lagoons would support mosquitoes in areas of reduced circulation, often associated with emergent vegetation. Vegetation management in lagoons would be subject to the BMPs in Table 4-6 to avoid or minimize impacts to environmental resources. With these BMPs, the effects of the Vegetation Management Alternative on biological resources within lagoons would be less-than-significant.

4.2.5.1.6 Tidal Marsh and Channels

Vegetation management activities are conducted in coordination with landowners or land managers and the resource agencies and generally focus on the removal of nondesired species. This work is done using hand tools and in accordance with the BMPs identified in Table 4-6, relating to agency coordination, environmental training, pre-treatment screening, disturbance minimization, tidal marsh and species-specific BMPs, and vegetation management-specific BMPs. With these BMPs, the effects of the Vegetation Management Alternative on biological resources within tidal marshes would be less-than-significant.

4.2.5.1.7 Water and Wastewater Treatment Facilities

Vegetation management activities may occur in coordination with the owners or operators of wastewater treatment facilities or septic systems. These facilities do not provide habitat for native or special-status fish or other aquatic species, although such facilities may lie close to suitable habitats in streams or the San Francisco Bay Delta system and connectivity may exist between the system and the natural environment that could allow aquatic resources to enter the system. The extent to which these species may enter these facilities is unknown. Because of the limited number of such facilities and the very limited use of such facilities by fish, amphibian or aquatic reptiles, vegetation management measures would have a less-than-significant impact on aquatic resources.

Winery waste ponds generally contain waste from grape pressings and washwater from cleaning winery equipment. These ponds generally do not provide suitable habitat for special-status species, as they are highly managed and often suffer from low water quality. In Marin County, the permitting of these ponds is controlled by the County Division of Environmental Health Services and in Sonoma County by the Permit and Resource Management Department. In both cases, the local permitting agency deals with flows of up to 10,000 gallons per day and with subsurface disposal only. If the daily flow exceeds this value or surface disposal is used, the RWQCB is the controlling agency. These entities require that vegetation within the waste ponds to be managed to prevent the creation of risks to public health. The District provides input relating to controlling mosquitoes and other vectors associated with the ponds and winery operations. The District may ask the landowner to implement vegetation management measures where appropriate. Because of the poor quality habitat provided and because physical control activities would rarely be conducted in these waste ponds, there is little likelihood of impacts to special-status species.

Flood control channels and ditches may support special-status species where they have standing water for sufficient periods of time and have suitable physical and vegetative structure. The application of the BMPs in Table 4-6, particularly those pertaining to agency communication, pre-treatment screening, and environmental training, would avoid impacts to any special-status species that might occur in these habitats.

4.2.5.1.8 Artificial Containers, Temporary Standing Waters and Ornamental Ponds

Vegetation management would not performed for artificial containers, temporary standing waters or ornamental ponds, as these areas would not support substantial stands of vegetation.

4.2.5.1.9 Impact Determinations for Special-Status Species and Habitats

Impact AR-13. The Vegetation Management Alternative would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.

Impact AR-14. The Vegetation Management Alternative would have a **less-than-significant** impact on any riparian habitat or other sensitive natural community. No mitigation is required.

Impact AR-15. The Vegetation Management Alternative would not result in the direct removal, filling, or hydrological interruption of federally protected wetlands as defined by CWA Section 404. As such, this alternative and would have a have a **less-than-significant** impact on these resources. No mitigation is required.

4.2.5.2 Effects on Movement and Migration

This alternative could have a small effect on the migration of wildlife and movement and migration corridors. The removal of small areas of vegetation would not substantially affect movement corridors, but the presence of personnel and machinery may result in short term avoidance of active work areas. In all cases this would be a short-term occurrence, generally not more than a few days in any given location and, therefore, this effect would be minimal and would have little impact on the movement of any native resident or migratory fish or wildlife and would not impact wildlife migration corridors or nursery areas, as little to no physical disturbance would occur.

Impact AR-16. The Vegetation Management Alternative would have a **less-than-significant** impact on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites. No mitigation is required.

4.2.5.3 Conflict with Local Ordinances

The county and city general plans and their goals and policies pertaining to natural resources are protective of aquatic resources and focused on conservation of existing resources. Vegetation management activities would not result in the conversion of natural habitats to other land uses or in the long-term or permanent dislocation of plant and animal species from natural areas except indirectly for mosquitoes and vectors of disease and discomfort. Vegetation removal would not affect trees more than 4 inches diameter at breast height and, therefore, would not conflict with local tree ordinances.

Impact AR-17. The Vegetation Management Alternative would have **no impact** on local policies or ordinances protecting biological resources.

4.2.5.4 Conflict with Conservation Plans

Two conservation plans, Turkey Road and the SRPCS, were identified whose action area is within the District's primary Service Area. The Turkey Road HCP provides for protection and mitigation of impacts to California red-legged frog associated with residential and vineyard development. The SRPCS provides for the protection and mitigation of impacts to California tiger salamander and four listed plant species from development on the Santa Rosa Plain.

The District conducts limited vegetation control operations within the area covered by the regional SRPCS. The District regularly communicates with and works collaboratively with the SRPCS IRT (also referred to as the Implementation Committee) and representatives from agencies such as RWQCB, USEPA, USACE, CDFW, and USFWS. The District receives training from agency staff and independent biologists (e.g., CDFW, USACE) to minimize impacts and conducts annual field training for field staff regarding precautionary and avoidance measures related to vernal pool habitat. The District uses specialized equipment in conjunction with vernal pool habitats.

Six conservation plans affect portions of adjacent counties. District activities are typically not among those covered by these HCPs. When called into these adjacent counties to perform work, the District would operate under the auspices of the county or that county's mosquito and vector control district and in compliance with their practices and permits, including compliance with all active HCP/NCCPs. Therefore, the District activities would not be in conflict with the provisions of any adopted HCP, NCCP, or other approved local, regional, or state-approved conservation plan.

Impact AR-18. The Vegetation Management Alternative would have a **less-than-significant** impact on adopted HCPs or NCCPs. No mitigation is required.

4.2.6 Biological Control Alternative

4.2.6.1 Impacts to Special-Status Species

This alternative consists of the introduction of mosquito predators, specifically mosquitofish (*Gambusia affinis*), into habitats occupied by mosquito larvae. These fish are ideal candidates for this use because they are highly tolerant of a wide range of temperature and water quality conditions, they can reproduce rapidly, and they are highly effective at locating and consuming mosquito larvae. Mosquitofish are also opportunistic omnivores, eating other invertebrates when they are more abundant and feeding on algae during times when insects are not abundant. This species can affect aquatic food webs. They are known to feed on fish and amphibian eggs and larvae (Moyle 2002; Nico et al. 2013). Mosquitofish can compete with other small fish for food and can also prey on other fish and insect mosquito predators when those species are present.

The District's purchase and use of mosquitofish in a given situation is given careful consideration with regard to the potential ecological consequences of such introductions. District policy is to limit the use of mosquitofish to artificial aquatic habitats (e.g., ornamental fish ponds, water troughs, water gardens, fountains, waste and industrial ponds, and unmaintained swimming pools) that do not connect to natural waterbodies and, therefore, where they do not pose a threat to natural environments or native fish and amphibians. Other types of isolated man-made ponds that do not provide habitat that could support native species could be treated with mosquito fish. These artificial habitats are not included in HCP/NCCPs. Mosquitofish would not be introduced into any of the other habitat types. This alternative would not result in any noise related effects.

Mosquito control agents such as Bs (a live bacteria) or Bti, and *Saacharopolyspora spinosa* (bacteria byproducts) may be considered biological controls, but are regulated by USEPA. Therefore, they are addressed in the Chemical Control Alternative. Currently, no commercial biological control agents or products are available for wasp and yellow jacket control, and the District does not employ predators (e.g., cats) for rodent control.

Impact AR-19. The Biological Control Alternative would have **no impact** either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species.

4.2.6.2 Impacts to Habitats

The use of mosquitofish under the Biological Alternative would not affect any natural habitats or result in the presence of District personnel or equipment in natural habitats. Therefore, it would not affect the quantity or distribution of habitats, such as riparian areas, marshes, lakes or ponds, seasonal wetlands, or habitat types identified in local or regional plans, policies, regulations, or by the CDFW or USFWS. This alternative would not affect the composition of their vegetative community. This alternative would not result in any ground-disturbing activity and, therefore, would not result in any removal, filling or hydrologic interruption of federally protected wetlands (including, but not limited to, marsh, vernal pool, coastal, etc.).

Impact AR-20. The Biological Control Alternative would have **no impact** on any riparian habitat or other sensitive natural community.

Impact AR-21. The Biological Control Alternative would have **no impact** on federally protected wetlands as defined by CWA Section 404.

4.2.6.3 Effects on Movement and Migration

This alternative would not occur in natural environments and would have no effect on the movement of wildlife and would not affect wildlife migration or movement corridors.

> **Impact AR-22.** The Biological Control Alternative would have **no impact** on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites.

4.2.6.4 Conflict with Local Ordinances

The county and city general plans and their goals pertaining to natural resources are protective of aquatic resources and focused on conservation of existing resources. Biological control activities with mosquitofish would not result in the conversion of natural habitats to other land uses or in the long-term or permanent dislocation of plant and animal species from natural areas except for mosquitoes and vectors of disease and discomfort. This alternative would not affect trees more than 4 inches diameter breast height and, therefore, would not conflict with local tree ordinances.

> **Impact AR-23.** The Biological Control Alternative would have **no impact** on local policies or ordinances protecting biological resources.

4.2.6.5 Conflict with Conservation Plans

Two conservation plans, Turkey Road and the SRPCS, were identified whose action area is within the District's primary Service Area. The Turkey Road HCP provides for protection and mitigation of impacts to California red-legged frog associated with residential and vineyard development. The SRPCS provides for the protection and mitigation of impacts to California tiger salamander and four listed plant species from development on the Santa Rosa Plain.

Biological control with mosquitofish would not be implemented within the boundaries of these conservations plans, unless appropriate protocols as required by the USFWS demonstrated that special-status species did not occupy that habitat and such habitat did not connect to other waters that could support special-status species.

The District regularly communicates with and works collaboratively with the SRPCS IRT (also referred to as the Implementation Committee) and representatives from agencies such as RWQCB, USEPA, USACE, CDFW, and USFWS.

Six conservation plans affect portions of adjacent counties. The District would not implement biological controls within the boundaries of these plan areas. When called into these adjacent counties to perform work, the District would operate under the auspices of the county or that county's mosquito and vector control district and in compliance with their practices and permits, including compliance with all active HCP/NCCPs. Therefore, the District activities would not be in conflict with the provisions of any adopted HCP, NCCP, or other approved local, regional, or state-approved conservation plan.

> **Impact AR-24**. The Biological Control Alternative would have **no impact** on approved HCPs, NCCPs, or local conservation plans.

4.2.7 Chemical Control Alternative

The Chemical Control Alternative would be primarily a continuation of existing activities using applicable techniques, equipment, vehicles, watercraft, and aircraft. A wide variety of chemicals and formulations are available for use to control mosquitoes and other adult insect vectors. These chemicals can be used as mosquito larvicides, adulticides, or both. Chemical control is also used to control nuisance populations of yellow jackets. The District does not currently perform control work with respect to tick populations but may potentially do a limited amount of control work in the future. The District does not use chemical control for rodents and nuisance wildlife.

Chemical control is a Program tool that consists of the application of nonpersistent insecticide products demonstrated to reduce populations of larval or adult mosquitoes and other vectors (e.g., yellow jacket wasps). If and when inspections reveal that mosquitoes or other vector populations are present at levels that trigger the District's guidelines for chemical control – based on the vector's abundance, density, species composition, proximity to human settlements, water temperature, presence of predators and other factors – staff will apply pesticides to the site in strict accordance with the pesticide label instructions and the BMPs summarized in Section 4.2.2 and listed in Table 4-6. The threshold guidelines for these response triggers are based on previous documentation and monitoring/current surveillance of likely vector outbreaks or population expansions. Additional response triggers are based on verified mosquito/vector populations, outbreaks, discomfort and irritation issues for humans and animals, and public concern about vectors.

A wide variety of chemicals and formulations are available for use to control mosquitoes. These chemicals can be used as mosquito larvicides, adulticides, or both. Chemical control may also be used to control populations of yellow jackets and ticks. The pesticide products used by the District are listed in Tables 2-2 through 2-4 in Chapter 2. Table 4-8 presents the chemical classes and their toxicity to fish and nontarget aquatic invertebrates. The synthetic pyrethroids allethrin, deltamethrin, and esfenvalerate are the materials under consideration by the District for use to control ticks in limited areas.

Table 4-8 Chemical Classes and their Toxicity[1] to Fish and Nontarget Aquatic Invertebrates

Class	Chemical	Mechanism of Action	Toxicity to	
			Fish	Nontarget Invertebrates
Mosquito Larvicides				
Bacterial Larvicides	Bs, Bti, spinosad	Paralyzes gut or disrupts central nervous system	Low	Low
Hydrocarbon esters	Methoprene and s-methoprene	Interferes with maturation process of insects	Moderate	High
Surfactants	Alcohol ethoxylated surfactant, aliphatic solvents (i.e., BVA-2, CoCo Bear oil), plant-derived oils	Drowns pupae and larvae	Very low	Affects Only Surface Breathing Insects
Mosquito Adulticides				
Pyrethrins	pyrethrin I and II, cinerin I and II, and jasmolin I and II	Causes persistent activation of the sodium channels on insect neurons resulting in "knock-down" agent	High	High
Pyrethroids	phenothrin, resmethrin, tetramethrin, permethrin, etofenprox	Interferes with operation of sodium channels in insect neurons	High	High
Synergist	Piperonyl butoxide	Synergist. Enhances operation of other active ingredients by inhibiting their breakdown	Moderate to High	High

Table 4-8 Chemical Classes and their Toxicity[1] to Fish and Nontarget Aquatic Invertebrates

Class	Chemical	Mechanism of Action	Toxicity to	
			Fish	Nontarget Invertebrates
Yellow Jackets and Ticks				
Pyrethrins	pyrethrin I and II, cinerin I and II, and jasmolin I and II	Causes persistent activation of the sodium channels on insect neurons resulting in "knock-down" agent	High	High
Pyrethroids	Allethrins, and d-*trans*-allethrin, deltamethrin, tetramethrin, phenothrin, permethrin, esfenvalerate, etofenprox	Interferes with operation of sodium channels in insect neurons	High	High
Synergist	Piperonyl butoxide	Synergist. Enhances operation of other active ingredients by inhibiting their breakdown	Moderate to High	High

[1] Toxicity information is summarized for each group from the information provided in Appendix B (Table 6-1).

[2] The toxicity data are derived from rigidly controlled laboratory animal studies designed to determine the potential adverse effects of the chemical under several possible routes of exposure (see Appendix B for further information). In these studies, the species of interest is continuously exposed to 100 percent chemical at several doses. In actual practice, the amounts applied in the District's Program Area are substantially less than the amounts used in the toxicity studies and organisms are not continuously exposed to the chemical. Furthermore, actual application rates by the District may be less than label requirements. Thus, the laboratory test results do not provide a realistic assessment of field exposure.

These chemicals are used in accordance with all applicable BMPs as listed in Table 4-6, CDPH's *Best Management Practices for Mosquito Control in California*, the Statewide General NPDES Permit for Biological and Residual Pesticide Discharges to Waters of the US from Spray Applications (SWRCB Water Quality Order No. 2011-0004-DWQ; NPDES No. CAG 990007; Spray Applications Permit) and District-specific BMPs as indicated in the PAPs and APAPs. All of these measures are designed to minimize impacts to nontarget organisms.

The toxicity data included in the tables in this section are generally derived from rigidly controlled laboratory animal studies designed to determine the potential adverse effects of the chemical under several possible routes of exposure. In these studies, the species of interest is exposed to 100 percent chemical at several doses to determine the lowest concentration resulting in a predetermined adverse effect (lowest observed adverse effect level [LOAEL]) on numerous selected physiological and behavioral systems. The second component of these tests is to determine the highest concentration of chemical that results in no measurable adverse effect (no observed adverse effect level [NOAEL]). These two levels are used to describe the potential range of exposures that could result in adverse effects, including the highest dose with no observed effects.

However, these, and other, coordinated and focused laboratory tests are designed to document the effects of the chemical when a continuous, controlled, exposure exists and do not realistically reflect the likely exposures or toxicity in the District field application scenarios. As such, the toxicity information is intended as an overview of potential issues and guidance for understanding the maximum exposure levels of applications that would not adversely impact humans or nontarget plant and animal species.

Although the regulatory community uses this basic information to provide a relative comparison of the potential for a chemical to result in unwanted adverse effects and this information is reflected in the

approved usage labels and MSDSs,[6] in actual practice, the amounts applied by the District in the District's Program Area for vector control are often substantially less than the amounts used in the laboratory toxicity studies. Because of the large safety factors used to develop recommended product label application rates, the amount of chemical resulting in demonstrated toxicity in the laboratory is much higher than the low exposure levels associated with an actual application for vector control. The application concentrations consistent with the labels or MSDSs are designed to be protective of the health of humans and other nontarget species (i.e., low enough to not kill them, weaken them, or cause them to fail to reproduce). Thus, adverse effects may still occur to some nontarget organisms. However, the chemicals would be applied in strict accordance with label directions, and BMPs contained in Table 4-6, including those relating to worker environmental awareness training, and disturbance minimization measures. The specific BMPs covering "Applications of Pesticides, Surfactants, and/or Herbicides" would be applied, as would appropriate habitat and species-specific BMPs. These practices make it highly unlikely that this alternative would result in adverse effects to special-status species or their habitats.

This assessment also considers the physical and biological connections between treatment areas and aquatic ecosystems. These chemicals are assessed by the vectors they are primarily used to control, and are grouped within these vectors into classes based on their composition, mechanism of action, and relative effect on aquatic resources (Tables 4-3 and 4-4). This section focuses on the potential impacts of these chemicals on fish, amphibians, aquatic reptiles, and aquatic invertebrates. These chemicals are discussed in greater detail in Chapter 6, Ecological Health, and in Appendix B.

Pesticides may be applied using motorized equipment including trucks, ARGOs, watercraft, and rotary or fixed-wing aircraft operating at low altitudes. Each application is expected to take less than a day (perhaps two days for larger areas), and thus the noise effects would be temporary. This would be expected to have the largest effect on adult amphibians when they are out of the water (or on terrestrial animals, discussed in Chapter 5), and would cause them to move away from the work area. Impacts to purely aquatic organisms from noise and vibration are not expected to occur.

4.2.7.1 Impacts to Special-Status Species

4.2.7.1.1 Mosquito Larvicides

Mosquito larvicides are applied to aquatic and wetland environments that surveillance has identified as having substantial concentrations of mosquito larvae. Larvicides may be applied in any of the aquatic and wetland habitat types previously listed. Special care is used when treating vernal pool habitats because of the number of special-status invertebrate species endemic to these habitats. The District predominantly applies Bti, Bs mosquito treatment is required in vernal pools. If mosquitoes reach the late stages of development in the larval cycle, methoprene may be applied (e.g., methoprene liquid). Surfactants (i.e., oils or monomecular films) are typically not applied to vernal pools; however an application of these materials may be considered if an abundance of mosquitoes in the pupal stage are present and present a potential threat to public health.

Bacterial Larvicides

These larvicides are developed from bacteria that have natural insecticidal properties. Concentrates are prepared that include fermentation solids, bacterial spores, and insecticidal toxins. These larvicides act by paralyzing the gut when ingested, causing the mosquito larvae to starve. Because Bs is a live bacterial pathogen of mosquitoes it may persist in the environment for 2 to 4 weeks; Bti, which is nonliving and consists of protein spores and crystals, generally persists for 1 to 4 days.

[6] Although the MSDS format is referenced in this document, it should be noted that under the international Globally Harmonized System, the MSDS format has been substantially revised and is now largely replaced by standardized Safety Data Sheets (SDSs).

Neither Bs nor Bti are acutely toxic to nontarget species including fish and invertebrates, nor are they toxic to predators of mosquito larvae (Appendix B). Bti may affect some dipterans (chironomids, simullids, ceratopogonids, and dixids), but only at concentrations 10 to 1,000 times higher than what is allowed for mosquito control.

Spinosad is a biologically derived insecticide produced from the fermentation of *Saccharopolyspora spinosa*, a naturally occurring soil organism. Spinosad activates the central nervous system of insects through interaction with neuroreceptors and causes continuous stimulation of the insect nervous system. In water, spinosad is degraded primarily through photolysis, and has a half-life of less than 1 day. It is slightly to moderately toxic to fish and most aquatic invertebrates. It may have slight impacts on some aquatic invertebrates with chronic exposure, but application for mosquitoes tends to be episodic, and given the rapid breakdown of spinosad in the environment, chronic exposure is unlikely.

Hydrocarbon Esters

Methoprene is an insect growth regulator and selective larvicide. Methoprene is used primarily against mosquitoes, but can also be used at much higher concentrations for the control of flies, moths and butterflies, and beetles. Methoprene interferes with the development of larval insects, preventing them from becoming adults. Within the aquatic environment, methoprene has a half-life of a few hours to a couple of days, but is sometimes applied in an extended release format, which may persist for many days or even months in the environment. Methoprene is effective for mosquito control at concentrations of up to 5.0 micrograms per liter (µg/L), with the District generally applying it at a maximum concentration of 2.4 – 4.8 (µg/L). At these application rates, some effects may occur to some nontarget midges (*Chironomidae*) and blackflies (*Simuliidae*), but these populations recover quickly after treatment (Appendix B; Maffei, pers. comm., 2013). No other invertebrates have shown signs of toxicity at these concentrations. Methoprene can be toxic to fish, but the lowest median lethal dose[7] (LD50 4.62 milligrams per kilogram [mg/L]) is several orders of magnitude greater (over 9,000 times) than the dose used by the District to control mosquitoes. The District infrequently applies methoprene to vernal pools. Methoprene may be applied when mosquito populations are abundant in the pools and when mosquitoes have reached the later stages of development.

Considered one of the least environmentally disruptive larvicides available, the District uses methoprene prevalently during each season of the year. Liquid and granular forms are used in residential and ornamental pond application scenarios. Treatments to wetlands, including marshes, at times require the granular form (e.g., Altosid pellets) to penetrate dense aquatic vegetation including cattails and tules. See Section 9.2.7.1 for discussion of use of methoprene in malfunctioning onsite wastewater treatment systems due to improper lid seals, cracks, or missing vent screens and/or due to drain fields where water ponds on the surface.

Surfactants

Surfactants (mostly alcohol ethoxylated surfactants, aliphatic solvents, and plant-derived oils) work by making it difficult for mosquito larvae and pupae to attach to the water's surface, causing them to drown. Surfactants affect only the uppermost layer of the water. The use of these materials is employed when absolutely necessary to prevent emergence of mosquito populations. They are nontoxic to most organisms at label application rates, but may impact other surface-breathing aquatic insects. The numbers of these nontarget surface-breathing insects were temporarily reduced following treatment, but recovered within a few days at Don Edwards Wildlife Area (Miles et al. 2002). These short-term impacts on a small portion of the food chain and in a limited area within a wetland are unlikely to result in substantive impacts to nontarget species in the aquatic environment.

[7] LD50 refers to the lethal single dose of a chemical (amount of chemical regardless of the volume of liquid in which it is delivered) that that would kill 50 percent of a group of test animals treated with that dose.

Impact AR-25: The Chemical Control Alternative's mosquito larvicides would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.

4.2.7.1.2 Mosquito Adulticides

In addition to chemical control of mosquito larvae, the District may use pesticides for control of adult mosquitoes as a component of the IVMP, for example, when other tools are not effective or appropriate and adult mosquito control guidelines are met, including species composition, abundance (as measured by landing count or other quantitative method), proximity to human populations, and/or human disease risk. Adulticide materials are used only as needed to control adult mosquito populations. However, adulticides are generally the last tool used, when mosquito populations cannot or have not been controlled at their source using physical control or larvicides. Adulticides are applied from the ground via truck, ATVs, utility vehicles, or handheld devices as an ULV application.

Aerial adulticiding could be used in the future to deal with a severe outbreak or risk of mosquito-borne disease transmission. Aerial applications would be made using ULV techniques. Aerial application of adulticide may be the only reliable means of obtaining effective control in areas bordered by extensive mosquito production sites with a small, narrow, or inaccessible network of roads, or to cover a very large area quickly in case of unusually severe mosquito outbreaks or vector-borne disease epidemics. In making the decision to use this technique, the District considers the potential effects on human health and the potential for environmental harm. For example, the maximum application rate of an adulticide that could be used is 0.87 ounce/acre, although maximum application rates are generally not required. The concentration of the active ingredient is 5 percent or less of this volume. This translates into a water concentration of 1.04 µg/L if the water is one foot deep or 4.14 µg/L if the water is three inches deep. This assumes all of the product contacts the water. Aerial applications are made over vegetated areas preferred by adult mosquitoes, so the amount of product encountering the water is generally a fraction of this. The chemicals used are selected for rapid breakdown and are typically present for a few hours to a couple of days after application.

Pyrethrins and Synthetic Pyrethroids

Pyrethrins are naturally occurring products distilled from the flowers of the *Chrysanthemum* species. Pyrethroid insecticides are synthetic compounds that are chemically similar to the pyrethrins that have been modified to increase stability and activity against insects. They are highly potent insecticides, that can be highly toxic to fish and aquatic invertebrates as well, sometimes at environmental concentrations of less than 1 µg/L. The presence of these pesticides in aquatic environments can result in lethal and sublethal effects on fish and aquatic invertebrates. Where substantial numbers of such organisms are affected, food supplies can be diminished, resulting in indirect effects to secondary and tertiary consumers dependent on the aquatic food web, including aquatic invertebrates, fish, amphibians, and birds. Both sets of compounds tend to break down relatively quickly in the environment, often within hours, and usually within a few days. Of the pyrethroids that are applied adjacent to aquatic environments, phenothrin and permethrin are more persistent than the other chemicals in this group, with half lives of days to months in water under aerobic conditions.

Pyrethrins and pyrethroids are applied in ULV applications by aircraft, truck, ATV, or handheld foggers and include pyrethrins, phenothrin, and permethrin. Numerous studies have found that these ULV applications result in concentrations in the aquatic environment of 0.23 to 3.77 µg/L and had little to no effect on fish or nontarget aquatic invertebrates (see Appendix B).

Piperonyl Butoxide

PBO is a synergist, a chemical applied with a pesticide to enhance the effectiveness of the pesticide (Appendix B). PBO works by interfering with an insect's ability to detoxify pyrethrins and pyrethroids. PBO is moderately toxic to fish (LD50=1.9 to 3.94 mg/L) and moderately to highly toxic) to aquatic invertebrates (0.51 to 12.0 mg/L). However, its toxicity is much lower than that of the pesticides it is used with. PBO can break down relatively rapidly by photolysis (half-life of 8.4 hours), but has a half-life exceeding 30 days based on aerobic metabolism in water. Although it degrades rapidly, release of PBO to the environment may "activate" persistent pyrethroids that are already present in the sediment. Field tests indicate that PBO concentrations were very low (~2 µg/L) immediately after 3 consecutive nights of treatment, declined rapidly thereafter, and was undetectable 8 days after application (see Appendix B). A number of studies indicate that PBO, when applied at the levels used for mosquito control, did not have any detectable effect on sentinel species (Appendix B). These studies also indicate that PBO does not persist in the environment very long after application. This information indicates that the use of PBO will not substantially affect aquatic organisms.

> **Impact AR-26**: The Chemical Control Alternative's mosquito adulticides would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.

4.2.7.1.3 Yellow Jacket and Tick Abatement

The District may use pesticides (typically pyrethrin and some pyrethroids) to control yellow jackets and ticks that pose an imminent threat to people or pets, generally because of public requests for assistance. These pesticides are highly toxic to fish and aquatic invertebrates, as described in Section 4.2.7.2. For control of yellow jackets and ticks, these pesticides are applied in highly localized, upland areas.

Examples of pesticides the District might employ to control yellow jackets and/or ticks in residential or upland environments are: allethrin and d-*trans* allethrin, deltamethrin, esfenvalerate, phenothrin, and tetramethrin. These compounds would only be expected to enter the aquatic environment through runoff. All degrade rapidly and bind readily to soil, so they are not anticipated to enter aquatic environments in sufficient quantities to result in adverse effects.

A few of the pyrethroids are bioaccumulative in fish, meaning that they can occur in organisms at higher concentrations than what occurs in the environment. These bioaccumulative pyrethroids include deltamethrin and esfenvalerate. However, these pyrethroids are applied directly into yellow jacket nests, and so would not enter the aquatic environment. The District typically does not engage in tick control activities, but could in the event of a tick borne disease outbreak. In such an event, the pesticides esfenvalerate and/or deltamethrin, would not be deployed close to water, as this is not preferred habitat for ticks. Therefore, these compounds are not expected to affect fish or other aquatic organisms.

Because of the small quantity of pesticide applied and because these chemicals are not applied directly to aquatic environments, this control method would have little impact on aquatic organisms.

> **Impact AR-27.** The Chemical Control Alternative's control of yellow jackets and ticks would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special- status species. No mitigation is required.

4.2.7.2 Impacts to Habitats

The Chemical Control Alternative would not affect the quantity or distribution of habitats, such as riparian areas, marshes, lakes or ponds, seasonal wetlands, or habitat types identified in local or regional plans, policies, regulations, or by the CDFW or USFWS. This alternative would not affect the composition of their vegetative communities, as the pesticides used would not be expected to affect plants or their physical or hydrologic attributes. This alternative would not result in any ground-disturbing activity and, therefore,

would not result in any removal, filling, or hydrologic interruption of federally protected wetlands (including but not limited to, marsh, vernal pool, coastal, etc.). The use of adulticides has not been required in direct association with mosquito production in vernal pools and this is not anticipated to be an issue in the foreseeable future. If adulticide use were to become necessary within close proximity (relative to swath widths of ULV application equipment) to vernal pools, applications would be performed in strict accordance with the product label, using the appropriate BMPs as listed in Table 4-6, and in consultation with property owners.

Impact AR-28. The Chemical Control Alternative would have **no impact** on any riparian habitat or other sensitive natural community

Impact AR-29. The Chemical Control Alternative would not result in the direct removal, filling, or hydrological interruption of federally protected wetlands as defined by CWA Section 404 and would have a have **no impact** on these resources.

4.2.7.3 Effects on Movement and Migration

Any disruption of migration patterns would be due to the presence of personnel and machinery in the environment. In all cases this would be a very short-term occurrence, generally not more than a few hours in any given location and, therefore, this effect would be minimal and would have little effect on the movement of wildlife and would not affect wildlife migration corridors or nursery areas, as no physical disturbance would occur.

Impact AR-30. The Chemical Control Alternative would have a **less-than-significant** impact on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites. No mitigation is required.

4.2.7.4 Conflict with Local Ordinances

The county and city general plans and their goals and policies pertaining to natural resources are protective of aquatic resources and focused on conservation of existing resources. Chemical control activities would not result in the conversion of natural habitats to other land uses or in the long-term or permanent dislocation of plant and animal species from natural areas except indirectly for mosquitoes and vectors of disease and discomfort. The Program would not affect trees more than 4 inches diameter breast height and, therefore, would not conflict with any tree ordinances.

Impact AR-31. The Chemical Control Alternative would have **no impact** on local policies or ordinances protecting biological resources.

4.2.7.5 Conflict with Conservation Plans

Two conservation plans, Turkey Road and the SRPCS, were identified whose action area is within the District's primary Service Area. The Turkey Road HCP provides for protection and mitigation of impacts to California red-legged frog associated with residential and vineyard development. The SRPCS provides for the protection and mitigation of impacts to California tiger salamander and four listed plant species from development on the Santa Rosa Plain.

The District may conduct chemical control operations within the area covered by the regional SRPCS. The District regularly communicates with and works collaboratively with the SRPCS IRT (also referred to as the Implementation Committee) and representatives from agencies such as RWQCB, USEPA, USACE, CDFW, and USFWS. The District receives training from agency staff and independent biologists (e.g., CDFW, USACE) to minimize impacts and conducts annual field training for field staff regarding precautionary and avoidance measures related to vernal pool habitat. The District uses specialized equipment in conjunction with vernal pool habitats.

Six conservation plans affect portions of adjacent counties. District activities are typically not among those covered by these HCPs. When called into these adjacent counties to perform work, the District would operate under the auspices of the county or that county's mosquito and vector control district and in compliance with their practices and permits, including compliance with all active HCP/NCCPs. Therefore, the District activities would not be in conflict with the provisions of any adopted HCP, NCCP, or other approved local, regional, or state-approved conservation plan.

> **Impact AR-32**. The Chemical Control Alternative would have a **less-than-significant** impact on approved HCPs, NCCPs, or local conservation plans. No mitigation is required.

4.2.8 Other Nonchemical Control/Trapping Alternative

The trapping of rodents is conducted as part of disease surveillance/testing programs and may be utilized for surveillance and egregious situations regarding commensal rodents (e.g., roof rats and Norway rats) in the future. Rodent trapping is not and will not be performed routinely as a mass trapping control measure. Trapping of yellow jackets is conducted when these organisms pose a threat to public health and welfare. For yellow jackets, District staff place the tamper-resistant or baited trap(s) primarily at the request of the property owner or manager, although they also advise the landowner that trapping is generally ineffective at population control and that it is better to seek out and treat the nest. The District does not remove rats or yellow jackets that are in or on structures. When these requests for service are made, residents are referred to the local animal control or to a directory of private pest control companies.

4.2.8.1 Impacts to Special-Status Species

The Other Nonchemical Control/Trapping Alternative is focused on trapping rodents, yellow jackets, and other organisms not associated with aquatic environments. This activity would not impact aquatic environments or the species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the CDFW or USFWS that occupy these environments and, therefore, would not affect them.

> **Impact AR-33.** The Other Nonchemical Control/Trapping Alternative would have **no impact** either directly or through habitat modifications, on any aquatic species identified as a candidate, sensitive, or special-status species.

4.2.8.2 Impacts to Habitats

This alternative would not affect the quantity or distribution of habitats, such as riparian areas, marshes, lakes or ponds, seasonal wetlands, or other habitat types identified in local or regional plans, policies, regulations, or by the CDFW or USFWS. This alternative would not affect the composition of their vegetative communities as the placement of traps and baits would not affect plants. This alternative would not result in any ground-disturbing activity and, therefore, would not result in any removal, filling or hydrologic interruption of federally protected wetlands (including but not limited to, marsh, vernal pool, coastal, etc.).

> **Impact AR-34.** The Other Nonchemical Control/Trapping Alternative would have **no impact** on any riparian habitat or other sensitive natural community.

> **Impact AR-35.** The Other Nonchemical Control/Trapping Alternative would have **no impact** on federally protected wetlands as defined by CWA Section 404.

4.2.8.3 Effects on Movement and Migration

Any disruption of migration patterns would be due to the presence of personnel to set traps in the environment. In all cases this would be a very short-term occurrence, generally not more than a few hours in any given location and, therefore, this effect would be minimal and would have little effect on the movement of wildlife and would not affect wildlife migration corridors or nursery areas, as no physical disturbance would occur.

> **Impact AR-36.** The Other Nonchemical Control/Trapping Alternative would have **no impact** on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites.

4.2.8.4 Conflict with Local Ordinances

The county and city general plans and their goals and policies pertaining to natural resources are protective of aquatic resources and focused on conservation of existing resources. Nonchemical control/trapping activities would not result in the conversion of natural habitats to other land uses or in the long-term or permanent dislocation of plant and animal species from natural areas. The Program would not affect trees more than 4 inches diameter breast height and, therefore, would not conflict with any tree ordinances.

> **Impact AR-37.** The Other Nonchemical Control/Trapping Alternative would have **no impact** on local policies or ordinances protecting biological resources.

4.2.8.5 Conflict with Conservation Plans

Two conservation plans, Turkey Road and the SRPCS, were identified whose action area is within the District's primary Service Area. The Turkey Road HCP provides for protection and mitigation of impacts to California red-legged frog associated with residential and vineyard development. The SRPCS provides for the protection and mitigation of impacts to California tiger salamander and four listed plant species from development on the Santa Rosa Plain.

Nonchemical controls including trapping would not be implemented within the boundaries of these conservations plans, unless appropriate protocols as required by the USFWS demonstrated that special-status species did not occupy that habitat and such habitat did not connect to other waters that could support special-status species.

The District regularly communicates with and works collaboratively with the SRPCS IRT (also referred to as the Implementation Committee) and representatives from agencies such as RWQCB, USEPA, USACE, CDFW, and USFWS.

Six conservation plans affect portions of adjacent counties. The District would not implement biological controls within the boundaries of these plan areas. When called into these adjacent counties to perform work, the District would operate under the auspices of the county or that county's mosquito and vector control district and in compliance with their practices and permits, including compliance with all active HCP/NCCPs. Therefore, the District activities would not be in conflict with the provisions of any adopted HCP, NCCP, or other approved local, regional, or state-approved conservation plan.

> **Impact AR-38**. The Other Nonchemical Control/Trapping Alternative would have **no impact** on approved HCPs, NCCPs, or local conservation plans.

4.2.9 Cumulative Impacts

Cumulative impacts on aquatic resources are discussed in Section 13.2. The determination is whether a proposed project's incremental contribution to a cumulative impact results in a potentially "considerable" (i.e., significant) cumulative impact is summarized herein.

The following is a summary of the Program impacts that could become cumulatively considerable with other impacts in the region. To make this determination, consideration is given to the combined contribution of Program impacts considered together with impacts that exist outside of the Program Area.

4.2.9.1 Regional Fisheries Trends

4.2.9.1.1 Pelagic Organism Decline (POD)

POD refers to the recent (2002–present) steep decline of pelagic fishes (i.e., fish that occupy open-water habitats) within the Bay-Delta estuary (Armor et al. 2005; CDWR and CDFG 2007; Sommer 2007; Baxter et al. 2010). This environmental issue has emerged as one of overwhelming concern in the Delta.

As the District borders on San Pablo Bay, the Physical Control and Vegetation Management alternatives could contribute to landscape habitat modifications, while the Chemical Control Alternative could contribute to contaminants:

> The District's Physical Control and Vegetation Management alternatives are limited to small areas of highly modified habitat. Because these areas are not primary habitat for POD species and because the areas where these activities occur are very small relative to the overall area of wetlands in the region, these activities are not expected to have any substantive effect on food production for POD species. Therefore, these alternatives do not contribute substantially to POD.

> The Chemical Control Alternative includes the use of pyrethrin and pyrethroid pesticides, which have been linked to POD. The District uses pyrethrin and pyrethroid pesticides as part of an IPM approach, where application of these materials is several levels down in the selection of control measures, so the use of pyrethrins and pyrethroids is limited. When pyrethrins and pyrethroids are used, the District preferentially uses those with limited persistence in the environment. The District uses pyrethroids over aquatic habitats using only ULV applications, which results in the minimal effective amounts of these chemicals. Thus, the Chemical Control Alternative does not contribute substantially to the concentrations of pyrethroids in the environment or to the POD.

> The Surveillance, Biological Control, and Other Nonchemical Control Alternatives involve access, monitoring, and control activities with very limited potential to impact POD.

Therefore, all of the Program alternatives have a **less-than-significant cumulative impact on POD**.

4.2.9.1.2 Salmonid Population Trends

Salmonid population trends were evaluated in a number of 5-year status reviews completed by NOAA Fisheries in 2011 (NOAA Fisheries 2011 a-f). These reviews indicated that most populations of salmonids showed some evidence of decline. However, based on the status reviews for these species, the principal factors resulting in their listing include:

> Loss, degradation, simplification, and fragmentation of habitat caused by a variety of activities including logging, road construction, urban development, mining activities, agriculture, ranching, and recreation

> Reduction or elimination of habitat or blocked access to habitat caused by water storage, withdrawal, conveyance and diversion facilities for agriculture, flood control, and domestic and hydropower purposes

> Point and nonpoint sources of pollution

> Loss of riparian habitats

The Physical Control and Vegetation Management alternatives could contribute to the first and last factors, while the Chemical Control Alternative could contribute to the third factor. These activities generally occur over small areas and have little impact on primary salmonid habitat. The BMPs that would be implemented as part of these alternatives substantially reduces these potential effects, so that the resultant effect is less than significant at the Program level, and does not contribute substantially to the total amount of habitat loss for salmonids in the region. The Surveillance, Biological Control, and Other Nonchemical Control Alternatives involve access, monitoring, and control activities with no potential to impact salmonids. Therefore, all of the Program alternatives have a **less-than-significant cumulative impact on salmonid population trends**.

4.2.9.2 Program Alternatives

The Surveillance Alternative's maintenance of access routes and the sampling/ monitoring of mosquito and vector populations have less-than-significant impacts on aquatic habitats, native fish or aquatic invertebrates, special-status species, or HCPs and NCCPs. This alternative, along with the Biological Control Alternative's use of mosquitofish in artificial/man-made waterbodies and the trapping associated with the Other Nonchemical Control Alternative are not cumulatively considerable given their minimal disruption to natural habitats. Consequently, the focus of the analysis below is on the Physical Control, Vegetation Management, and Chemical Control Alternatives.

4.2.9.2.1 Physical Control Alternative

The draining or filling of shallow-water habitats in natural areas under the Physical Control Alternative would be cumulative with historic and ongoing impacts to these habitats from other land management practices including flood control, urbanization, and channelization. The majority of such activities occurring as part of the action would occur in artificial environments such as drainage ditches, retention ponds, etc.

Activities affecting wetlands are subject to permitting requirements from a variety of agencies including the USACE, SWRCB or RWQCBs, CDFW, BCDC, and others. However, wetlands continue to be affected by urban and agricultural development, roadwork, and other activities (Resource Agency 2010), an existing significant cumulative impact. The District's activities within this context do not contribute substantially to the cumulative effects of other activities within the region in part due to the constraints of required permits. Therefore, the Program would have a **less-than-significant cumulative impact on the amount or quality of aquatic habitat**.

4.2.9.2.2 Vegetation Management Alternative

The vegetation within and around aquatic habitats is an important component of the aquatic ecosystem, as described in Section 4.2.5.

Invasive weeds and vegetation can disrupt native habitats. They compete with and may displace native plants, which may interfere with ecosystem functions, by altering and reducing the food resources available to primary and secondary consumers. Vegetation control activities the District(s) perform would be cumulative with those performed by other entities. These activities would focus on areas with dense concentrations of weeds and not on individual weed plants distributed broadly in otherwise natural habitats. Thus, vegetation control activities may affect native plants, as these species may lie within treatment areas, but the effects on individuals of native species are minimized, and the overall effect is likely beneficial, as native species will have less competition in treated areas and, thus, would be expected to be more successful. Therefore, there is not an existing significant cumulative impact to native habitats. The District's incremental activities associated with the **control of invasive weeds and vegetation would not be cumulatively considerable or less than significant**.

4.2.9.2.3 Chemical Control Alternative

The uses of pesticides under the Chemical Control Alternative would be cumulative with uses of pesticides by agricultural, industrial, governmental, and residential users, an existing significant cumulative impact. Contaminants and pesticides have been hypothesized to contribute to declines in fish populations. The District's relative contribution to the loads of such concentrations is small compared with other users. Applications of pesticides for vector control are most often at concentrations less than the maximum allowed on the product label, and nontarget species are not substantially affected and acute toxicities are avoided. The amounts applied by the District for vector control are often substantially less than the amounts used in the laboratory toxicity studies. Because of the large safety factors used to develop recommended product label application rates, the amount of chemical resulting in demonstrated toxicity in the laboratory is much higher than the low exposure levels associated with an actual application for vector control. The District preferentially uses nonchemical alternatives and when using chemical alternatives, uses chemicals that are not persistent in the environment when chemicals are applied. As such, the District's Chemical Control Alternative does not contribute substantively to pesticide and herbicide loads in the aquatic environment. The Chemical Control Alternative has a **less-than-significant cumulative impact on herbicide and pesticide loads**.

4.2.10 Environmental Impacts Summary

Table 4-9 provides a summary of the environmental impacts of the Program alternatives on aquatic resources. Discussion of these impacts is provided in the preceding sections.

Table 4-9 Summary Biological Aquatic Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Effects on Biological Resources – Aquatic						
Impact AR-1. The Surveillance Alternative would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	LS	na	na	na	na	na
Impact AR-2. The Surveillance Alternative would have a **less-than-significant** impact on any riparian habitat or other sensitive natural community No mitigation is required.	LS	na	na	na	na	na
Impact AR-3. The Surveillance Alternative would have a **less-than-significant** impact on federally protected wetlands as defined by Section 404 of the Clean Water Act. No mitigation is required.	LS	na	na	na	na	na
Impact AR-4. The Surveillance Alternative would have **no impact** on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites.	N	na	na	na	na	na
Impact AR-5. The Surveillance Alternative would have **no impact** on local policies or ordinances protecting biological resources.	N	na	na	na	na	na
Impact AR-6. The Surveillance Alternative has a **less-than-significant** impact on any adopted HCPs or NCCPs. No mitigation is required.	LS	na	na	na	na	na
Impact AR-7. The Physical Control Alternative, would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	LS	na	na	na	na
Impact AR-8. The Physical Control Alternative would have a **less-than-significant** impact on any riparian habitat or other sensitive natural community. No mitigation is required.	na	LS	na	na	na	na

Table 4-9 Summary Biological Aquatic Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact AR-9. The Physical Control Alternative would have a **less-than-significant** impact on federally protected wetlands as defined by Section 404 of the Clean Water Act. No mitigation is required.	na	LS	na	na	na	na
Impact AR-10. The Physical Control Alternative would have a **less-than-significant impact on** the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites. No mitigation is required.	na	LS	na	na	na	na
Impact AR-11. The Physical Control Alternative would have **no impact** on local policies or ordinances protecting aquatic resources.	na	N	na	na	na	na
Impact AR-12. The Physical Control Alternative would have a **less-than-significant** impact on adopted HCPs or NCCPs. No mitigation is required.	na	LS	na	na	na	na
Impact AR-13. The Vegetation Management Alternative would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	na	LS	na	na	na
Impact AR-14. The Vegetation Management Alternative would have a **less-than-significant** impact on any riparian habitat or other sensitive natural community. No mitigation is required.	na	na	LS	na	na	na
Impact AR-15. The Vegetation Management Alternative would not result in the direct removal, filling, or hydrological interruption of federally protected wetlands as defined by CWA Section 404. As such, this alternative and would have a have a **less-than-significant** impact on these resources. No mitigation is required.	na	na	LS	na	na	na

Table 4-9 Summary Biological Aquatic Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact AR-16. The Vegetation Management Alternative would have **a less-than-significant** impact on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites. No mitigation is required.	na	na	LS	na	na	na
Impact AR-17. The Vegetation Management Alternative would have **no impact** on local policies or ordinances protecting biological resources.	na	na	N	na	na	na
Impact AR-18. The Vegetation Management Alternative would have a **less-than-significant** impact on adopted HCPs or NCCPs. No mitigation is required.	na	na	LS	na	na	na
Impact AR-19. The Biological Control Alternative would have **no impact** either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species.	na	na	na	N	na	na
Impact AR-20. The Biological Control Alternative would have **no impact** on any riparian habitat or other sensitive natural community.	na	na	na	N	na	na
Impact AR-21. The Biological Control Alternative would have **no impact** on federally protected wetlands as defined by CWA Section 404.	na	na	na	N	na	na
Impact AR-22. The Biological Control Alternative would have **no impact** on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites.	na	na	na	N	na	na
Impact AR-23. The Biological Control Alternative would have **no impact** on local policies or ordinances protecting biological resources.	na	na	na	N	na	na
Impact AR-24. The Biological Control Alternative would have **no impact** on approved HCPs, NCCPs, or local conservation plans.	na	na	na	N	na	na

Table 4-9 Summary Biological Aquatic Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact AR-25: The Chemical Control Alternative's mosquito larvicides would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	na	na	na	LS	na
Impact AR-26: The Chemical Control Alternative's mosquito adulticides would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	na	na	na	LS	na
Impact AR-27. The Chemical Control Alternative's control of yellow jackets and ticks would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	na	na	na	LS	na
Impact AR-28. The Chemical Control Alternative would have **no impact** on any riparian habitat or other sensitive natural community	na	na	na	na	N	na
Impact AR-29. The Chemical Control Alternative would not result in the direct removal, filling, or hydrological interruption of federally protected wetlands as defined by CWA Section 404 and would have a have **no impact** on these resources.	na	na	na	na	N	na
Impact AR-30. The Chemical Control Alternative would have a **less-than-significant** impact on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites. No mitigation is required.	na	na	na	na	LS	na
Impact AR-31. The Chemical Control Alternative would have **no impact** on local policies or ordinances protecting biological resources.	na	na	na	na	N	na

Table 4-9 Summary Biological Aquatic Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact AR-32. The Chemical Control Alternative would have a **less-than-significant** impact on approved HCPs, NCCPs, or local conservation plans. No mitigation is required.	na	na	na	na	LS	na
Impact AR-33. The Other Nonchemical Control/Trapping Alternative would have **no impact** either directly or through habitat modifications, on any aquatic species identified as a candidate, sensitive, or special-status species.	na	na	na	na	na	N
Impact AR-34. The Other Nonchemical Control/Trapping Alternative would have **no impact** on any riparian habitat or other sensitive natural community.	na	na	na	na	na	N
Impact AR-35. The Other Nonchemical Control/Trapping Alternative would have **no impact** on federally protected wetlands as defined by CWA Section 404.	na	na	na	na	na	N
Impact AR-36. The Other Nonchemical Control/Trapping Alternative would have **no impact** on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites.	na	na	na	na	na	N
Impact AR-37. The Other Nonchemical Control/Trapping Alternative would have **no impact** on local policies or ordinances protecting biological resources.	na	na	na	na	na	N
Impact AR-38. The Other Nonchemical Control/Trapping Alternative would have **no impact** on approved HCPs, NCCPs, or local conservation plans.	na	na	na	na	na	N

LS = Less-than-significant impact
N = No impact
na = Not applicable
SM = Potentially significant but mitigable impact
SU = Significant and unavoidable impact

4.2.11 Mitigation and Monitoring

The implementation of the alternatives would not result in any significant impacts on aquatic or wetland resources. All impacts are either less-than-significant or none. Therefore, no mitigation is required.

5 Biological Resources – Terrestrial

Chapter 5 evaluates the potential impacts of the Program alternatives on terrestrial resources. Results of the evaluation are provided at the programmatic level. Section 5.1, Environmental Setting, presents an overview of the environmental settings and contains federal regulations, state regulations, and local ordinances and regulations that are applicable to the Program. Section 5.2, Environmental Impacts and Mitigation Measures, presents the following:

> Environmental concerns and evaluation criteria: A discussion of whether the Program alternatives would cause any potentially significant impacts to terrestrial resources and addressing concerns from the public scoping

> Discussion of methods and assumptions important to the environmental impact analysis, including findings from Appendix B, *Ecological and Human Health Assessment*, and best management practices (BMPs)

> Discussion of the potential impacts of the Program alternatives, and recommendations for mitigation, if required, for those impacts

> Cumulative impacts summary

> A summary of environmental impacts to terrestrial resources

Aquatic resources are addressed in Chapter 4, *Biological Resources - Aquatic*. Impacts to ecological health with an emphasis on chemical use (including bioaccumulation/biomagnification) are addressed in Chapter 6, *Ecological Health*.

5.1 Environmental Setting

The Program Area is defined as the Marin/Sonoma Mosquito and Vector Control District's (MSMVCD or District) Program Area and adjacent counties (see Figure 2-1 in Chapter 2). The following section provides background information on the terrestrial resources that may be present and an overview of the regulatory setting with respect to management of terrestrial species.

Section 5.1.1 describes the habitat types used in evaluating Program impacts within the District's Program Area, Section 5.1.2 describes the special-status terrestrial species that have the potential to occur within the Program Area, Section 5.1.3 provides an overview of federal, state, and local ordinances and regulations pertinent to these resources that are applicable to the Program. Section 4.1.4 identifies the Habitat Conservation Plans (HCPs) and Natural Community Conservation Plans (NCCPs) in the Program Area. Background information on hazards, toxicity, and exposure is provided in Section 5.2.2.2.

5.1.1 Terrestrial Resources within the Program Area

The District Service Area is located in Marin and Sonoma counties, and the Program Area addressed in this report also includes the four surrounding counties: Mendocino, Lake, Napa, and Solano. This area encompasses a range of terrestrial habitats and a diverse array of wildlife and plants. Fish, amphibian and aquatic reptile species are included as aquatic species and discussed in Chapter 4.

To facilitate the evaluation of impacts and impact avoidance measures by habitat type, a consistent set of habitat types was developed for terrestrial areas (Table 5-1). Terrestrial habitat types were based on those developed as part of the San Francisco Bay Area Upland Habitat Goals Project (Bay Area Open Space Council 2011). The aquatic and wetland habitats defined in Section 4.1.1 are also discussed in this section to address potential impacts to terrestrial species found in association with those aquatic habitats.

Table 5-1 Terrestrial Habitat Types

Coniferous Forests	Forests dominated by cone-bearing trees with needles including pines, firs and redwoods
Deciduous Forest	Forests dominated by trees that drop leaves annually including buckeyes, oaks (including live oaks) and maples
Shrublands	Dense to moderate stands of coyote brush, ceanothus, poison oak, sage, sagebrush, chamise and diverse other shrubs with grassy openings
Grasslands	Grasslands dominated by annual grasses, with varying amounts of native perennials
Serpentine	Shrublands or grasslands on serpentine rock
Coastal Dunes	Sandy soils with some active sand movement supporting low stands of diverse native perennials and beach grass
Treeholes	Cavities in branches and trunks of live trees or snags that can provide habitat for a variety of species

Source: Goals Project 1999

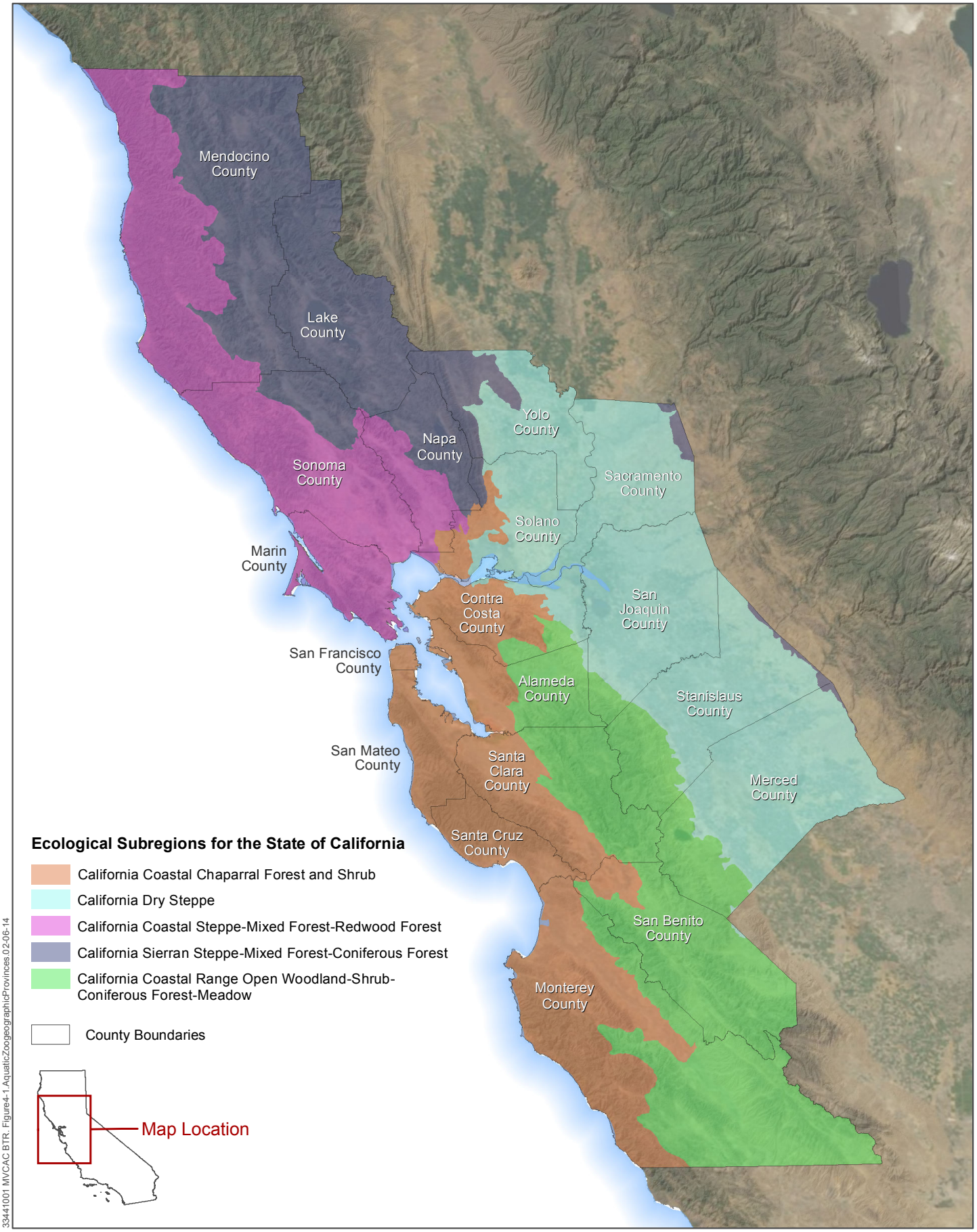
The ecoregion provinces (McNab and Avers 1996) have been used to describe the areas where the Program activities and treatments would be implemented and are shown on Figure 5-1. The ecoregion provinces are described in Appendix A, *Biological Resources Technical Report*.

Control activities may also be provided in areas adjacent to the District's Service Area upon request of the adjacent jurisdictions to protect the health and safety of residents in adjacent jurisdictions. Actions that would be taken outside of the District's Service Area are the same types of actions undertaken within the Service Area and in similar types of habitats or sites. Where activities are taken outside the District's immediate Service Area, these activities would be taken in collaboration with the adjacent county or mosquito and vector control district.

Each of these habitat types may be affected by one or more of the Program alternatives, as indicated in Table 5-2. The Program alternatives are described in Chapter 2, and the BMPs that will be applied to avoid and minimize potential impacts to these habitat types are provided in Table 5-3.

Table 5-2 Terrestrial Habitat Types Potentially Affected by Each Program Alternative

	Surveillance	**Physical Control**	**Vegetation Management**	**Biological Control**	**Chemical Control**	**Other Nonchemical Control / Trapping**
Coniferous Forest	X		X		X	X
Deciduous Forest	X		X		X	X
Shrublands	X		X		X	X
Grasslands	X		X		X	X
Serpentine	X		X		X	X
Coastal Dunes	X		X		X	X
Treeholes	X	X	X		X	X



33441001 MVCAC BTR. Figure4-1.AquaticZoogeographicProvinces.02-06-14

Source: US Forest Service, Pacific Southwest Region, Ecological Subregions for the State of California

INTEGRATED VECTOR MANAGEMENT PROGRAM

Terrestrial Ecoregion Provinces

Figure 5-1

Table 5-3 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid / Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other	Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Treeholes	Creeks and Rivers	Riparian Corridor	Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	FW Marsh/Seeps	Seasonal Wetlands (includes Vernal Pools)	Lagoon	Tidal Marsh and channels	Water and Wastewater Management Facilities	Artificial Containers, Temporary Standing Waters and Ornamental Ponds
A. General BMPs																						
1. District staff has had long standing and continues to have cooperative, collaborative relationships with federal, state, and local agencies. The District regularly communicates with agencies regarding the District's operations and/or the necessity and opportunity for increased access for surveillance, source reduction, habitat enhancement, and the presence of special-status species and wildlife. The District often participates in and contributes to interagency projects. The District will continue to foster these relationships, communication, and collaboration.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2. In particular, District staff will regularly communicate with resource agency staff regarding vector management operations, habitat, and flora and fauna in sensitive habitats. Such communications will include wildlife studies and occurrences of sensitive species in areas that may be subject to vector management activities.	X	X	X	*	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X
3. When walking or using small equipment in marshes, riparian corridors, or other sensitive habitats, existing trails, levees and access roads will be used whenever possible to minimize or avoid impacts to species of concern and sensitive habitats. Specific care will be taken when walking and performing surveillance in the vicinity of natural and man-made ditches or sloughs or in the vicinity of tidal marsh habitat.	X	X	X	*[1]	X	X								X	X	X	X	X	X	X		
4. District staff has received training from USFWS and CDFW biologists regarding endangered species, endangered species habitat, and wildlife/wildlife habitat recognition and avoidance measures. District supervisory staff frequently engages staff on these subjects. For example, District staff has become familiar with Ridgway's rail call recordings to invoke avoidance measures if these calls are heard in the field. District staff is trained to be observant, proceed carefully, and practice avoidance measures if needed when accessing areas that may serve as bird nesting habitat (e.g., watch for flushing birds that may indicate a nest is nearby). Emphasis will be placed on species and habitats of concern where vector management activities might occur (e.g., SMHM, RIRA, special-status plants, vernal pools, tidal marsh, etc.). These training sessions will be included as a part of the safety training records that are kept by vector control agencies.	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

[1] (*) means not available at this time. Should a viable biocontrol agent become available, evaluation of BMP measures would occur and be implemented.

Table 5-3 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid / Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other	Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Treeholes	Creeks and Rivers	Riparian Corridor	Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	FW Marsh/Seeps	Seasonal Wetlands (includes Vernal Pools)	Lagoon	Tidal Marsh and channels	Water and Wastewater Management Facilities	Artificial Containers, Temporary Standing Waters and Ornamental Ponds
5. Conduct worker environmental awareness training for all treatment field crews and contractors for special-status species and sensitive natural communities that a qualified person (e.g., District biologist) determines to have the potential to occur on treatment sites. Conduct the education training prior to starting work at the treatment site and upon arrival of any new worker onto sites with the potential for special-status species or sensitive natural communities.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6. District staff will work with care and caution to minimize potential disturbance to wildlife while performing surveillance and vector treatment/population management activities (see 1 through 5 above).	X	X	X	*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7. Identify probable (based on historical experience) treatment sites that may contain habitat for special-status species every year prior to work to determine the potential presence of special-status flora and fauna using the CNDDB, relevant Habitat Conservation Plans (HCPs), NOAA Fisheries and USFWS websites, Calfish.org, and other biological information developed for other permits. Establish a buffer of reasonable distance, when feasible, from known special-status species locations and do not allow application of pesticides/herbicides within this buffer without further agency consultations. Nonchemical methods are acceptable within the buffer zone when designed to avoid damage to any identified and documented rare flora and fauna.	X	X	X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8. Vehicles driving on levees to travel through tidal marsh or to access sloughs or channels for surveillance or treatment activities will travel at speeds no greater than 10 miles per hour to minimize noise and dust disturbance.	X	X	X		X	X														X		
9. District staff will implement site access selection guidelines to minimize equipment use in sensitive habitats including active nesting areas and to use the proper vehicles for onroad and offroad conditions.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
10. Properly train all staff, contractors, and volunteer help to prevent spreading weeds and pests to other sites. The District headquarters contains wash rack facilities (including high-pressure washers) to regularly (in many cases daily) and thoroughly clean equipment to prevent the spread of weeds.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
11. Operation of noise-generating equipment (e.g., chainsaws, wood chippers, brush-cutters, pickup trucks) will abide by the time-of-day restrictions established by the applicable local jurisdiction (i.e., City and/or County) if such noise activities would be audible to receptors (e.g., residential land uses, schools, hospitals, places of worship) located in the applicable local jurisdiction. Shut down all motorized equipment when not in use.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 5-3 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid / Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other	Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Treeholes	Creeks and Rivers	Riparian Corridor	Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	FW Marsh/Seeps	Seasonal Wetlands (includes Vernal Pools)	Lagoon	Tidal Marsh and channels	Water and Wastewater Management Facilities	Artificial Containers, Temporary Standing Waters and Ornamental Ponds
12. For operations that generate noise expected to be of concern to the public, the following measures will be implemented: – Measure 1: Provide Advance Notices: A variety of measures are implemented depending on the magnitude/nature of the activities undertaken by the District, and may include but are not limited to press releases, social media, District websites, emails, phone messages, hand-delivered flyers, and posted signs. Public agencies and elected officials also may be notified of the nature and duration of the activities, including the Board of Supervisors or City Council, environmental health and agricultural agencies, emergency service providers, and airports. – Measure 2: Provide Mechanism to Address Complaints. The District staff is available during regular business hours to respond to service calls and may staff phone lines to address concerns during nighttime operations.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
13. The District will perform public education and outreach activities.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
14. Engine idling times will be minimized either by shutting equipment and vehicles off when not in use or reducing the maximum idling time to 5 minutes. Clear signage will be provided for workers at all access points. Correct tire inflation will be maintained in accordance with manufacturer's specifications on wheeled equipment and vehicles to prevent excessive rolling resistance. All equipment and vehicles will be maintained and properly tuned in accordance with manufacturer's specifications. All equipment will be checked by a certified visible emissions evaluator if visible emissions are apparent to onsite staff.	X	X	X	X	X	X																

Table 5-3 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid / Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other	Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Treeholes	Creeks and Rivers	Riparian Corridor	Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	FW Marsh/Seeps	Seasonal Wetlands (includes Vernal Pools)	Lagoon	Tidal Marsh and channels	Water and Wastewater Management Facilities	Artificial Containers, Temporary Standing Waters and Ornamental Ponds
B. Tidal Marsh-Specific BMPs																						
1. District staff will continue to implement the measures in the USFWS's "Walking in the Marsh: Methods to Increase Safety and Reduce Impacts to Wildlife/Plants." District staff will receive annual training and review of this document to remain up to date and current on this document and its methodologies for protecting sensitive species and the marsh habitat.	X	X	X	*	X														X	X		
2. District will minimize the use of equipment (e.g., ARGOs) in tidal marshes and wetlands. When feasible and appropriate, surveillance and control work will be performed on-foot with handheld equipment. Aerial treatment (helicopter and fixed wing) treatments will be utilized when feasible and appropriate to minimize the disturbance of the marsh during pesticide applications. When ATVs (e.g., ARGOs) are utilized techniques will be employed that limit impacts to the marsh including: slow speeds; slow, several point turns; using existing levees or upland to travel through sites when possible; use existing pathways or limit the number of travel pathways used.	X	X	X	*	X	X													X	X		
3. District will minimize travel along tidal channels and sloughs to reduce impacts to vegetation used as habitat (e.g., Ridgway's rail nesting and escape habitat).	X	X	X		X														X	X		
4. District staff will minimize the potential for the introduction and spread of spartina, perennial pepperweed and other invasive plant species by cleaning all equipment, vehicles, personal gear, clothing, and boots of soil, seeds, and plant material prior to entering the marsh, and avoiding walking and driving through patches of perennial pepperweed to the maximum extent feasible.	X	X	X	*	X	X								X[1]		X[1]	X[1]	X[1]	X	X		
5. When feasible, boats will be used to access marsh areas for surveillance and treatment of vectors to further reduce the risk of potential impacts that may occur when using ATVs to conduct vector management activities.	X	X	X	*	X														X	X		

Table 5-3 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid / Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Alternative: Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other	Upland Habitats: Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Treeholes	Aquatic and Wetland Habitats: Creeks and Rivers	Riparian Corridor	Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	FW Marsh/Seeps	Seasonal Wetlands (includes Vernal Pools)	Lagoon	Tidal Marsh and channels	Water and Wastewater Management Facilities	Artificial Containers, Temporary Standing Waters and Ornamental Ponds
6. The District currently references and provides staff training relevant to the USFWS "Walking in the Marsh: Methods to Increase Safety and Reduce Impacts to Wildlife/Plants" guidelines (USFWS undated). – District staff is trained to walk carefully in the marsh and to continuously look ahead of themselves to avoid potential wildlife disturbance (e.g., carefully make observations in their surroundings to detect flushing birds and nests). Specific care is taken when walking and performing surveillance in the vicinity of natural and man-made ditches or sloughs or in vicinity of cord grass habitat (e.g., rack line). – When walking in marshes District staff utilizes existing trails when possible (i.e., deer trails and other preexisting trails).	X	X	X	X	X	X	X[2]	X[2]	X[2]	X[2]	X[2]	X[2]		X[2]			X[2]	X[2]	X	X		
C. Salt Marsh Harvest Mouse (SMHM)																						
1. Activities (surveillance, treatment, source reduction) within or adjacent to harvest mouse habitat will not occur within two hours before or after extreme high tides of 6.5 feet National Geodetic Vertical Datum (NGVD) or above as measured at the Golden Gate Bridge (corrected for time and tide height for the site) or when the marsh plain is completely inundated because suitable upland refugia cover is limited and potentially disturbance-creating activities could prevent mice from reaching available cover.	X	X	X	*	X	X													X	X		
2. Vegetation removal is limited to the minimum amount necessary to allow for surveillance, treatment, and vector habitat reduction (vegetation management) to minimize or avoid loss of SMHM. Similarly, excavation, fill, or construction activities will also be limited to the minimum amount necessary to minimize/avoid loss of SMHM.	X	X	X		X														X	X		
3. Vegetation clearing will be conducted systematically within the Program area to ensure that SMHM are encouraged to move toward remaining vegetation and are not trapped in islands of vegetation subject to removal and far from suitable cover.		X	X																X	X		
4. Each day, 30 minutes before commencement of vector habitat management (physical control, vegetation management) observations will be conducted for the presence of SMHM in the work area by staff trained by USFWS personnel in the safe and effective methods for observing SMHM.		X	X	*	X														X	X		

Table 5-3 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid / Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other	Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Treeholes	Creeks and Rivers	Riparian Corridor	Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	FW Marsh/Seeps	Seasonal Wetlands (includes Vernal Pools)	Lagoon	Tidal Marsh and channels	Water and Wastewater Management Facilities	Artificial Containers, Temporary Standing Waters and Ornamental Ponds
5. To the extent feasible, physical control, vegetation management and other vector habitat reduction activities will be conducted between December 1 and February 28 (outside of the SMHM breeding season). Surveillance, chemical control, biological control, and public education activities occur year-round and are therefore carefully coordinated with resource agencies to minimize potential impacts to SMHMs and their habitats.		X	X		X														X	X		
6. When walking in the marsh, existing trails will be used whenever possible. Specific care will be taken when walking and performing surveillance in the vicinity of natural and man-made ditches or sloughs or in the vicinity of tidal marsh habitat to avoid potential disturbance of SMHM.	X	X	X	*	X	X													X	X		
7. District staff will receive training on measures to avoid impacts to SMHM.	X	X	X	*	X	X													X	X		
8. If SMHM nests or adults are encountered during vector management activities, avoidance measures will be immediately implemented and findings will be reported to the appropriate resource agency.	X	X	X	*	X	X													X	X		
D. Ridgway's Rail (RIRA)																						
1. Activities (surveillance, treatment, source reduction) within or adjacent to RIRA habitat will not occur within two hours before or after extreme high tides of 6.5 feet National Geodetic Vertical Datum (NGVD) or above as measured at the Golden Gate Bridge (corrected for time and tide height for the site) or when the marsh plain is completely inundated because suitable upland refugia cover is limited and potentially disturbance-creating activities could prevent RIRAs from reaching available cover.	X	X	X	*	X	X													X	X		
2. Vegetation removal is limited to the minimum amount necessary to allow for surveillance, treatment, and vector habitat reduction (vegetation management) to minimize or avoid loss of RIRA. Similarly, excavation, fill, or construction activities will also be limited to the minimum amount necessary to minimize/avoid loss of RIRA.	X	X	X		X														X	X		
3. To the extent feasible, physical control, vegetation management and other vector habitat reduction activities will be conducted between September 1 and January 31 (outside of the RIRA breeding season). Surveillance, chemical control, biological control, and public education activities occur year-round and are therefore carefully coordinated with resource agencies to minimize potential impacts to RIRAs and their habitats.		X	X		X														X	X		

Table 5-3 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid / Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other	Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Treeholes	Creeks and Rivers	Riparian Corridor	Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	FW Marsh/Seeps	Seasonal Wetlands (includes Vernal Pools)	Lagoon	Tidal Marsh and channels	Water and Wastewater Management Facilities	Artificial Containers, Temporary Standing Waters and Ornamental Ponds
4. District staff will notify the appropriate resource agency prior to entering potential RIRA habitats and will regularly coordinate with the resource agency(ies) on the locations of breeding RIRAs and avoid breeding RIRAs to the extent feasible. Any observations of adverse effects to RIRAs will be reported by District staff.	X	X	X	X	X														X	X		
5. When walking in the marsh District staff will use existing trails whenever possible. Specific care will be taken when walking and performing surveillance in the vicinity of natural and man-made ditches or sloughs or in the vicinity of tidal marsh habitat to avoid potential disturbance of RIRAs.	X	X	X	*	X	X													X	X		
6. Entry into suitable breeding habitat for RIRAs will be minimized. When entry is required, the preferred method will be by foot. Other entry methods will be based on consultation with the appropriate resource agency.	X	X	X	*	X	X													X	X		
7. District staff will receive training on measures to avoid impacts to RIRAs.	X	X	X	*	X	X													X	X		
8. If RIRA nests or adults are encountered during vector management activities, avoidance measures, as provided during training from the resource agencies, will be immediately implemented and findings will be reported to the appropriate resource agency.	X	X	X	*	X	X													X	X		
E. Soft Bird's Beak																						
1. District staff will receive training on the identification, biology and preferred habitat of soft bird's beak.	X	X	X	*	X	X													X	X		
2. When possible, Program actions to be conducted in areas containing suitable habitat for this species will occur during the time period when soft bird's beak is in bloom and identifiable (July-November), so that any soft bird's beaks plants observed can be avoided and documented.	X	X	X	*	X	X													X	X		
3. District staff will coordinate with Napa-Sonoma Marshes Wildlife Area (CDFW) and San Pablo Bay National Wildlife Refuge regarding the locations of known soft bird's beak populations, so that these populations can be avoided. Flagging will be used to identify the boundaries of known soft bird's beak populations.	X	X	X	*	X	X													X	X		
4. When possible, vector management activities will be conducted on foot using hand equipment.	X	X	X	*	X	X													X	X		

Table 5-3 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid / Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other	Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Treeholes	Creeks and Rivers	Riparian Corridor	Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	FW Marsh/Seeps	Seasonal Wetlands (includes Vernal Pools)	Lagoon	Tidal Marsh and channels	Water and Wastewater Management Facilities	Artificial Containers, Temporary Standing Waters and Ornamental Ponds
F. Vegetation Management																						
1. Consultations will be made with the appropriate resource agency to discuss proposed vegetation management work, determine potential presence of sensitive species and areas of concern, and any required permits.		X	X											X	X	X	X	X	X	X		
2. Vegetation management work performed will typically be by hand, using handheld tools, to provide access to vector habitat for surveillance, and when needed control activities. Tools used include machetes, small garden-variety chainsaw, hedge trimmers, and "weed-eaters."		X	X											X	X	X	X	X	X	X		
3. District will consult and coordinate with resource agencies as well as have all necessary permits prior to the commencement of work using heavy equipment (e.g., larger than handheld/garden variety tools such as small excavators with rotary mowers) in riparian areas.		X	X											X	X	X	X	X	X	X		
4. Minor trimming of vegetation (e.g., willow branches approximately three inches in diameter or less, blackberry bushes, and poison oak) to the minimum extent necessary will occur to maintain existing paths or create access points through dense riparian vegetation into vector habitat. This may include minor trimming of overhanging limbs, brush and blackberry thickets that obstruct the ability to walk within creek channels. Paths to be maintained will not be a cut, defined corridor but rather a path maintained by selective trimming of overhanging or intrusive vegetation. Paths to be maintained will range in width from three to 6 feet across.		X	X												X							
5. Downed trees and large limbs that have fallen due to storm events or disease will be cut only to the extent necessary to maintain existing access points or to allow access to vector habitats.		X	X												X							
6. Vegetation management work will be confined to October 1 to April 30[2] to minimize potential impacts to sensitive species, especially breeding birds. When work is expected to occur between February 1 and April 30, additional consultations will occur with appropriate resource agencies to help identify locations of active nests of raptors or migratory birds as well as any additional protection measures that will need to be implemented prior to commencement of work.		X	X												X	X	X	X	X	X		

[2] Dates are from MSMVCD's Final LSAA permit with CDFW; Notification No. 1600-2010-2053-R3, Public Health/Mosquito Control Access Maintenance (October 6, 2010).

Table 5-3 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid / Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other	Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Treeholes	Creeks and Rivers	Riparian Corridor	Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	FW Marsh/Seeps	Seasonal Wetlands (includes Vernal Pools)	Lagoon	Tidal Marsh and channels	Water and Wastewater Management Facilities	Artificial Containers, Temporary Standing Waters and Ornamental Ponds
7. Every effort will be made to complete vegetation management in riparian corridors prior to the onset of heavy rains. Maintenance work to be done in early spring will be limited to trimming new growth, poison oak, blackberries, and downed trees that block these paths.		X	X												X							
8. District staff will work with care and caution to minimize potential disturbance to wildlife, while performing vegetation management activities within or near riparian corridors.		X	X											X	X	X	X	X	X	X		
9. Within suitable habitat for California Freshwater Shrimp (*Syncaris pacifica*), no in-channel vegetation will be removed, trimmed, or otherwise disturbed. District staff will work with resource agencies to determine locations of suitable habitat for California Freshwater Shrimp and receive written authorization to proceed prior to commencement of vegetation management activities.		X	X											X	X							
10. If suitable habitat necessary for special-status species is found, including vernal pools, and if nonchemical physical and vegetation management control methods have the potential for affecting special-status species, then the District will coordinate with the CDFW, USFWS, and/or NMFS before conducting control activities within this boundary or cancel activities in this area. If the District determines no suitable habitat is present, control activities may occur without further agency consultations.		X	X											X	X	X	X	X	X	X		
11. When using heavy equipment for vegetation management, District staff (and contractors) will minimize the area that is affected by the activity and employ all appropriate measures to minimize and contain turbidity. Heavy equipment will not be operated in the water and appropriate containment and cleanup systems will be in place on site to avoid, contain, and clean up any leakage of toxic chemicals.		X	X											X	X	X	X	X	X	X		

Table 5-3 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid / Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other	Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Treeholes	Creeks and Rivers	Riparian Corridor	Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	FW Marsh/Seeps	Seasonal Wetlands (includes Vernal Pools)	Lagoon	Tidal Marsh and channels	Water and Wastewater Management Facilities	Artificial Containers, Temporary Standing Waters and Ornamental Ponds
G. Maintenance / Construction and Repair of Tide Gates and Water Structures in Waters of the U.S.																						
1. District staff will consult with appropriate resource agencies (USACE, USFWS, CDFW, NMFS, BCDC, RWQCB) and obtain all required permits prior to the commencement of ditch maintenance or construction within tidal marshes.		X												X		X	X	X	X	X	X	
2. Work plans for the upcoming season proposed work as well as a summary of the last season completed work will be submitted for review and comment to USACE, USFWS, NMFS, CDFW, BCDC and RWQCB no later than July 1 of each year for which work is being proposed. The work plan will include a delineation of all proposed ditching overlain on topographic maps at a minimum of 1" = 1000' scale, with accompanying vicinity maps. The plan will also indicate the dominant vegetation of the site, based on subjective estimates, the length and width of the ditches to be maintained, cleared or filled, and the estimated date the work will be carried out.		X												X		X	X	X	X	X	X	
3. All maintenance work will be done at times that minimize adverse impacts to nesting birds, anadromous fish, and other species of concern, in consultation with USFWS, NMFS, and CDFW. Work conducted will, whenever possible, be conducted during approved in water work periods for that habitat, considering the species likely to be present. For example, tidal marsh work will be conducted between September 1 and January 31, where possible and not contraindicated by the presence of other sensitive species. Similarly, in water work in waterbodies that support anadromous fish, work will be conducted between July 1 and September 30[3].		X	X											X		X	X	X	X	X	X	
4. Care will be taken to minimize the risk of potential disruption to the indigenous aquatic life of a waterbody in which ditch maintenance is to take place, including those aquatic organisms that migrate through the area.		X												X		X	X	X	X	X	X	
5. Staging of equipment will occur on upland sites.		X												X		X	X	X	X	X	X	
6. Mats or other measures taken to minimize soil disturbance (e.g., use of low ground pressure equipment) when heavy equipment is used.		X												X		X	X	X	X	X	X	

[3] Dates are from District's USACE. Regional Permit 4, July 31, 2007.

Table 5-3 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid / Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other	Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Treeholes	Creeks and Rivers	Riparian Corridor	Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	FW Marsh/Seeps	Seasonal Wetlands (includes Vernal Pools)	Lagoon	Tidal Marsh and channels	Water and Wastewater Management Facilities	Artificial Containers, Temporary Standing Waters and Ornamental Ponds
7. All projects will be evaluated prior to bringing mechanical equipment on site, to identify and flag sensitive sites, select the best access route to the work site consistent with protection of sensitive areas, and clearly demarcate work areas.		X												X		X	X	X	X	X	X	
8. Measures will be taken to minimize impacts from mechanical equipment, such as hand ditching as much as possible; reducing turns by track-type vehicles, taking a minimum number of passes with equipment, varying points of entry, driving vehicles at low speed, and not driving on open mud and other soft areas.		X												X		X	X	X	X	X	X	
9. Discharges of dredged or fill material into tidal waters will be minimized or avoided to the maximum extent possible at the project site and will be consistent with all permit requirements for such activity. No discharge of unsuitable material (e.g., trash) will be made into waters of the United States, and material that is discharged will be free of toxic pollutants in toxic amounts (see section 307 of the Clean Water Act). Measures will be taken to avoid disruption of the natural drainage patterns in wetland areas.		X												X		X	X	X	X	X	X	
10. Discovery of historic or archeological remains will be reported to USACE and all work stopped until authorized to proceed by the appropriate regulatory authorities/resource agencies.		X												X		X	X	X	X	X	X	
11. Ditching that drains high marsh ponds will be minimized to the extent possible to protect the habitat of native salt pan species.		X																	X	X		
12. No spoils sidecast adjacent to circulation ditches will exceed 8 inches above the marsh plain to minimize risk of colonization of spoils by invasive, nonnative plants and/or the spoils lines from becoming access corridors for unwanted predators (e.g., dogs, cats, red fox). Sidecast spoil lines exceeding 4 inches in height above the marsh plain will extend no more than 6 feet from the nearest ditch margin. Any spoils in excess of these dimensions will be hydraulically redispersed on site (e.g., by rotary ditcher), or removed to designated upland sites (per conditions of resource agency issued permits). Sidecast spoil lines will be breached at appropriate intervals to prevent local impediments to water circulation.		X																	X	X		

Table 5-3 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid / Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other	Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Treeholes	Creeks and Rivers	Riparian Corridor	Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	FW Marsh/Seeps	Seasonal Wetlands (includes Vernal Pools)	Lagoon	Tidal Marsh and channels	Water and Wastewater Management Facilities	Artificial Containers, Temporary Standing Waters and Ornamental Ponds
13. If review of the proposed work plan by USACE, USFWS, or CDFW determines the proposed maintenance is likely to destroy or damage substantial amounts of shrubby or sub-shrubby vegetation (e.g., coyote brush, gumplant) on old sidecast spoils, the District will provide a quantitative estimate of the extent and quality of the vegetation, and provide a revegetation plan for the impacted species prepared by a biologist/botanist with expertise in marsh vegetation. The Corps approved revegetation plan will be implemented prior to April 1 of the year following the impacts.		X																	X	X		
14. Small ditch maintenance work will be performed by hand, whenever possible, using handheld shovels, pitch forks, etc., and small trimmers such as "weed-eaters." (Note: the majority of small ditch work performed by the District is by hand.)		X														X	X	X	X	X	X	
15. Work will be done at low tide (for tidal areas) and times of entry will be planned to minimize disruption to wildlife.		X												X	X	X	X	X	X	X	X	
16. In marshes which contain populations of invasive nonnative vegetation such as pepperweed or introduced spartina, sidecast spoils will be surveyed for the frequency of establishment of these species during the first growing season following deposition of the spoils. The results of the surveys will be reported to the USACE, USFWS and CDFW. If it is determined the sidecasting of spoils resulted in a substantial increase in the distribution or abundance of the nonnative vegetation which is detrimental to the marsh, the District will implement appropriate abatement measures after consultation with the USACE, USFWS and CDFW.		X																	X	X		
17. When possible (i.e., with existing labor and vehicles), refuse such as tires, plastic, and man-made containers found at the work site will be removed and properly discarded.		X	X											X		X	X	X	X	X	X	

Table 5-3 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid / Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other	Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Treeholes	Creeks and Rivers	Riparian Corridor	Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	FW Marsh/Seeps	Seasonal Wetlands (includes Vernal Pools)	Lagoon	Tidal Marsh and channels	Water and Wastewater Management Facilities	Artificial Containers, Temporary Standing Waters and Ornamental Ponds
H. Applications of Pesticides, Surfactants, and/or Herbicides																						
1. District staff will conduct applications with strict adherence to product label directions that include approved application rates and methods, storage, transportation, mixing, and container disposal.			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2. District will avoid use of surfactants when possible in sites with aquatic nontargets or natural enemies of mosquitoes present such as nymphal damsel flies and dragonflies, dytiscids, hydrophilids, corixids, notonectids, and ephydrids. Surfactants are the only tool that can be used with pupae to prevent adult mosquitos emergence, but generally the District will use a microbial larvicide (Bti, Bs) or insect growth regulator (e.g., methoprene) instead or another alternative when possible.			X		X								X	X	X	X	X	X	X	X	X	X
3. Materials will be applied at the lowest effective concentration for a specific set of vectors and environmental conditions. Application rates will never exceed the maximum label application rate.			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4. To minimize application of pesticides, application of pesticides will be informed by surveillance and monitoring of vector populations.			X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
5. District staff will follow label requirements for storage, loading, and mixing of pesticides and herbicides. Handle all mixing and transferring of herbicides within a contained area.			X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6. Postpone or cease application when predetermined weather parameters exceed product label specifications, when wind speeds exceed the velocity as stated on the product label, or when a high chance of rain is predicted and rain is determining factor on the label of the material to be applied.			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
7. Applicators will remain aware of wind conditions prior to and during application events to minimize any possible unwanted drift to waterbodies, and other areas adjacent to the application areas.			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
8. Spray nozzles will be adjusted to produce larger droplet size rather than smaller droplet size. Use low nozzle pressures where possible (e.g., 30 to 70 pounds per square inch). Keep spray nozzles within a predetermined maximum distance of target weeds (e.g., within 24 inches of vegetation for hand application) or vectors. Adjusting droplet size would only apply to larvicides, herbicides and non-ULV applications. Use ULV applications that are calibrated to be effective and environmentally compatible at the proper droplet size (about 10-30 microns).			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 5-3 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid / Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other	Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Treeholes	Creeks and Rivers	Riparian Corridor	Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	FW Marsh/Seeps	Seasonal Wetlands (includes Vernal Pools)	Lagoon	Tidal Marsh and channels	Water and Wastewater Management Facilities	Artificial Containers, Temporary Standing Waters and Ornamental Ponds
9. Clean containers at an approved site and dispose of at a legal dumpsite or recycle in accordance with manufacturer's instructions if available.			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
10. Special-Status Aquatic Wildlife Species: – A CNDDB search was conducted in 2012 and the results incorporated into Appendix A for this PEIR. An update was completed in November 2014 and the results incorporated into Section 4.1.2 of this PEIR. District staff communicates with state, federal, and county agencies regarding sites that have potential to support special-status species. Many sites where the District performs surveillance and control work have been visited by staff for many years and staff is highly knowledgeable about the sites and habitat present. If new sites or site features are discovered that have potential to be habitat for special-status species, the appropriate agency or landowner is contacted and communication initiated. – Use only pesticides, herbicides, and adjuvants approved for aquatic areas or manual treatments within a predetermined distance from aquatic features (e.g., within 15 feet of aquatic features). Aquatic features are defined as any natural or man-made lake, pond, river, creek, drainage way, ditch, spring, saturated soils, or similar feature that holds water at the time of treatment or typically becomes inundated during winter rains. – If suitable habitat for special-status species is found, including vernal pools, and if aquatic-approved pesticide, herbicide, and adjuvant treatment methods have the potential for affecting the potential species, then the District will coordinate with the CDFW, USFWS, and/or National Marine Fisheries Service (NMFS) before conducting treatment activities within this boundary or cancel activities in this area. If the District determines no suitable habitat is present, treatment activities may occur without further agency consultation.			X	*	X									X		X	X	X	X	X	X	
11. District staff will monitor sites post-treatment to determine if the target vector or weeds were effectively controlled with minimum effect to the environment and nontarget organisms. This information will be used to help design future treatment methods in the same season or future years to respond to changes in site conditions.			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 5-3 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid / Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other	Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Treeholes	Creeks and Rivers	Riparian Corridor	Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	FW Marsh/Seeps	Seasonal Wetlands (includes Vernal Pools)	Lagoon	Tidal Marsh and channels	Water and Wastewater Management Facilities	Artificial Containers, Temporary Standing Waters and Ornamental Ponds
12. Do not apply pesticides that could affect insect pollinators in liquid or spray/fog forms over large areas (more than 0.25 acres) during the day when honeybees are present and active or when other pollinators are active. Preferred applications of these specific pesticides are to occur in areas with little or no honeybee or pollinator activity or after dark. These treatments may be applied over smaller areas (with handheld equipment), but the technician will first inspect the area for the presence of bees and other pollinators. If pollinators are present in substantial numbers, the treatment will be made at an alternative time when these pollinators are inactive or absent.			X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
13. The District will provide notification to the public (24 – 48 hours in advance if possible) and/or appropriate agency(ies) when applying pesticides or herbicides for large-scale treatments (e.g., fixed-wing aircraft or helicopters) that will occur in close proximity to homes, heavily populated, high traffic, and sensitive areas. The District infrequently applies or participates in the application of herbicides in areas other than District facilities.			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
I. Hazardous Materials and Spill Management																						
1. Exercise adequate caution to prevent spillage of pesticides during storage, transportation, mixing or application of pesticides. Report all pesticide spills and cleanups (excepting cases where dry materials may be returned to the container or application equipment).			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2. Maintain a pesticide spill cleanup kit and proper protective equipment at the District's Service Yard and in each District truck used for pesticide transport.			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
3. Manage the spill site to prevent entry by unauthorized personnel. Contain and control the spill by stopping it from leaking or spreading to surrounding areas, cover dry spills with polyethylene or plastic tarpaulin, and absorb liquid spills with appropriate absorbent materials.			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
4. Properly secure the spilled material, label the bags with service container labels identifying the pesticide, and deliver them to a District/Field Supervisor for disposal.			X	*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 5-3 Marin/Sonoma Mosquito and Vector Control District BMPs to Avoid / Minimize Environmental Impacts by Alternative

Best Management Practice (BMP)	Alternative						Upland Habitats							Aquatic and Wetland Habitats								
	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other	Coniferous Forest	Deciduous Forest	Shrublands	Grasslands	Serpentine	Coastal Dunes	Treeholes	Creeks and Rivers	Riparian Corridor	Ponds and Lakes (includes stock and golf ponds that have natural bottoms)	FW Marsh/Seeps	Seasonal Wetlands (includes Vernal Pools)	Lagoon	Tidal Marsh and channels	Water and Wastewater Management Facilities	Artificial Containers, Temporary Standing Waters and Ornamental Ponds
5. A hazardous spill plan will be developed, maintained, made available, and staff trained on implementation and notification for petroleum-based or other chemical-based materials prior to commencement of vector treatment activities.	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
6. Field-based mixing and loading operations will occur in such a manner as to minimize the risk of accidental spill or release of pesticides.			X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

[1] This BMP will also be applied in aquatic habitats other than tidal marshes, although the weed species of concern would differ.

[2] This BMP will also be applied in all habitats.

5.1.2 Special-Status Species

A number of special-status species are found in the Program Area and vicinity. Special-status species are those that are listed as endangered, threatened, or candidate species under the federal Endangered Species Act, endangered or threatened under the California Endangered Species Act, or listed as species of special concern by the state. Special-status species' presence or absence within the Program Area are presented in (Table 4-3, California Natural Diversity Database Occurrences Plant Species in the Marin/Sonoma Mosquito and Vector Control District and its Adjacent Program Areas and in Table 4-4, California Natural Diversity Database Occurrences Animal Species in Marin/Sonoma Mosquito and Vector Control District and its Adjacent Program Areas) which also shows the habitat types these species are likely to use. All species were included in these tables in Chapter 4, to be comprehensive in one location and to avoid duplication herein, as a number of species occur in both wetland and upland habitat types.

5.1.3 Regulatory Setting

The regulatory setting includes the federal, state, and local laws, statues, and regulations pertinent to the Program Area and vicinity and the terrestrial resources residing therein. These laws include the following:

5.1.3.1 Federal

5.1.3.1.1 Endangered Species Act of 1973 (16 USC Section 1531 et seq.; 50 CFR Parts 17 and 222)

This law includes provisions for protection and management of species that are federally listed as threatened or endangered and designated critical habitat for these species. This law prohibits "take" of federally listed species, except as authorized under an incidental take permit or incidental take statement. The term "take" means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct (http://www.fws.gov/endangered/laws-policies/section-3.html). The USFWS is the administering agency for this authority for freshwater species. The NMFS is the administering agency for anadromous species.

5.1.3.1.2 Migratory Bird Treaty Act (16 USC Section(s) 703-711; 50 CFR Subchapter B)

This law includes provisions for protection of migratory birds, including basic prohibitions against any taking not authorized by federal regulation. The administering agency is the USFWS.

5.1.3.1.3 Bald and Golden Eagles Protection Act (16 USC Section(s) 668; 50 CFR Part 22)

This act makes it illegal to import, export, take (which includes molest or disturb[4]), sell, purchase, or barter any bald eagle or golden eagle or part thereof. The golden eagle, however, is accorded somewhat lighter protection under this act than the bald eagle. The administrating agency is the USFWS.

[4] "Disturb means to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, (1) injury to an eagle, (2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or (3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior.''

5.1.3.1.4 Clean Water Act of 1977 [33 USC Section(s) 1251-1376; 30 CFR Section(s) 330.5 (a)(26)]

These sections provide for the protection of wetlands. The administering agency for the above authority is the USACE. Under CWA Sections 301 and 502, any discharge of dredged or fill materials into "waters of the United States," including wetlands, is forbidden unless authorized by a permit issued by the USACE pursuant to Section 404. These permits are an essential part of protecting streams and wetlands. Wetlands are vital to the ecosystem in filtering streams and rivers and providing habitat for wildlife.

The USEPA is the federal agency responsible for water quality management and administers the federal Water Pollution Control Act Amendments of 1972 and 1987, collectively known as the Clean Water Act (CWA). The CWA establishes the principal federal statutes for water quality protection. It was established with the intent “to restore and maintain the chemical, physical, and biological integrity of the nation’s water, to achieve a level of water quality which provides for recreation in and on the water, and for the propagation of fish and wildlife.” Also see Section 9.1.2.1 in Chapter 9, *Water Resources*.

5.1.3.1.5 Executive Order 11990, Protection of Wetlands (May 24, 1977)

This order provides for the protection of wetlands. The administering agency for the above authority is the USACE.

5.1.3.1.6 Federal Insecticide, Fungicide, and Rodenticide Act

FIFRA defines a pesticide as “any substance intended for preventing, destroying, repelling, or mitigating any pest.” FIFRA requires USEPA registration of pesticides prior to their distribution for use in the US, sets registration criteria (testing guidelines), and mandates that pesticides perform their intended functions without causing unreasonable adverse effects on people and the environment when used according to USEPA-approved label directions. FIFRA defines an "unreasonable adverse effect on the environment" as "(1) any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of the pesticide, or (2) a human dietary risk from residues that result from a use of a pesticide in or on any food inconsistent with the standard under Section 408 of the Federal Food, Drug, and Cosmetic Act (21 USC 346a)."

FIFRA regulates only the active ingredients of pesticides, not inert ingredients, which manufacturers are not required to reveal. However, toxicity studies conducted under FIFRA are required to evaluate the active ingredient and the entire product formulation, through which any potential additive or synergistic effects of inert ingredients are established.

5.1.3.1.7 Stipulated Injunction and Order, Protection of California Red-Legged Frog from Pesticides

On October 20, 2006, the US District Court for the Northern District of California imposed no-use buffer zones around California red-legged frog upland and aquatic habitats for certain pesticides. This injunction and order will remain in effect for each pesticide listed in the injunction until the USEPA goes through formal 7(A)(2) consultation with the USFWS on each of the 66 active ingredients, and the USFWS issues a Biological Opinion including a “not likely to adversely affect” statement for the pesticides. Under the injunction and order, no-use buffer zones of 60 feet for ground applications and 200 feet for aerial applications apply from the edge of the following California red-legged frog habitats as defined by the USFWS and the Center for Biological Diversity: Aquatic Feature, Aquatic Breeding Habitat, Nonbreeding Aquatic Habitat, and Upland Habitat. These habitats are found in 33 counties of California including Marin and Sonoma counties.

Of the 66 pesticides listed in the injunction, the District may employ esfenvalerate, methoprene, and permethrin for vector control. Esfenvalerate may be used for yellow-jacket and wasp control in response to public complaints. Methoprene is used for larval mosquito control, and permethrin may be used for adult mosquito control. However, vector control programs are exempt. Specifically, for applications of a

pesticide for purposes of public health vector control under a program administered by a public entity, the injunction does not apply. The District may use the following herbicides listed in the injunction: glyphosate, imazapyr, and triclopyr. Where used for vegetation management for control of mosquito-breeding habitat, the injunction would not apply. If these herbicides were to be used for invasive species management to assist other agencies or landowners, then the injunction generally applies until such time that the material has been reviewed by USEPA and USFWS determines that it does not apply or the following "exceptions for invasive species and noxious weed programs" can be met:

a. You are applying a pesticide for purposes of controlling state-designated invasive species and noxious weeds under a program administered by a public entity; and

b. You do not apply the pesticide within 15 feet of aquatic breeding critical habitat or nonbreeding aquatic critical habitat within critical habitat areas, or within 15 feet of aquatic features within non-critical habitat sections subject to the injunction; and

c. Application is limited to localized spot treatment using handheld devices; and

d. Precipitation is not occurring or forecast to occur within 24 hours; and

e. You are a certified applicator or working under the direct supervision of a certified applicator; and

f. If using 2,4-D or triclopyr, you are using only the amine formulations. (USEPA 2014a).

5.1.3.2 State

5.1.3.2.1 Porter-Cologne Water Quality Control Act of 1970

This law provides the SWRCB and the nine RWQCBs with authority to establish Water Quality Control Plans (Basin Plans) that are reviewed and revised periodically. The SWRCB and the RWQCBs carry out the federal CWA, including the NPDES permitting process for point source discharges and the CWA Section 303 water quality standards program. The administering agencies are the SWRCB and the RWQCBs.

5.1.3.2.2 California Fish and Game Code Section 1600 et seq.

This law provides for protection and conservation of fish and wildlife resources with respect to any project that may substantially divert or obstruct the natural flow of, or substantially change or use any material from the bed, channel, or bank of any river, stream, or lake. The administering agency is the CDFW.

5.1.3.2.3 California Endangered Species Act of 1984 (California Fish and Game Code Sections 2050 2098)

This law provides for the protection and management of species and subspecies listed by the State of California as endangered or threatened, or designated as candidates for such listing. They are listed at 14 CCR Section 670.5. This law prohibits "take" of state-listed or candidate species, except as otherwise authorized by the Fish and Game Code. (The term "take" is defined by Section 86 of the Fish and Game Code as "hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill." This definition is different in some respects from the definition of "take" under the Federal Endangered Species Act.) The administering agency is the CDFW.

5.1.3.2.4 California Fish and Game Code §3503

This law prohibits take, possession, or needless destruction of any bird egg or nest, except as otherwise provided by the Fish and Game Code or regulation made pursuant thereto. The administering agency is the CDFW.

5.1.3.2.5 California Fish and Game Code §3503.5

This law prohibits take, possession, or destruction of any bird of prey (birds in the order of Falconiformes or Strigiformes), except as otherwise provided by the Fish and Game Code or regulation adopted pursuant thereto. The administering agency is the CDFW.

5.1.3.2.6 California Fish and Game Code §3511, 4700, and 5050

These laws prohibit take or possession of birds, mammals, and reptiles listed as "fully protected," except as provided by the Fish and Game Code. The administering agency is the CDFW.

5.1.3.2.7 California Fish and Game Code Section 5650

This law protects water quality from substances or materials deleterious to fish, plant life, or bird life. It prohibits such substances or materials from being placed in waters or places where they can pass into waters of the state, except as authorized pursuant to, and in compliance with, the terms and conditions of permits or authorizations of the SWRCB or a RWQCB such as a waste discharge requirement issued pursuant to California Water Code Section 13263, a waiver issued pursuant to Water Code Section 13269(a), or permit pursuant to Water Code Section 13160. The administering agency for Fish and Game Code Section 5650 is the CDFW.

5.1.3.2.8 Natural Community Conservation Planning Act (California Fish and Game Code §2800 to 2835)

This law provides for the development of NCCPs to provide for regional or areawide protection and perpetuation of natural wildlife diversity, while allowing compatible and appropriate development and growth. The administering agency is the CDFW.

5.1.3.2.9 Native Plant Protection Act; California Fish and Game Code §1900 et seq.

This law provides for the preservation, protection, and enhancement of endangered or rare native plants of the state. The Native Plant Protection Act allows for the designation of endangered and rare native plant species and states that no person shall take any native plant, or any part or product thereof that the commission has determined to be an endangered native plant or rare native plant, except as otherwise provided in the act. The administering agency is the CDFW.

5.1.3.2.10 California Food and Agricultural Code, Section(s) 12976 and Section(s) 12981

This code states that no pesticide application should be made or continued when a reasonable possibility exists of damage to nontarget crops, animals, or other public or private property. The administering agency for the above authority is the CDPR.

5.1.3.2.11 California Food and Agricultural Code, Section(s) 29102

This code provides for the protection of bees from pesticide use through notification of beekeepers and the establishment of citrus bee protection areas. Prohibited applications to citrus within a citrus/bee protection area include any pesticide toxic to bees, except those exempted in a subsequent subsection during a citrus bloom period, unless the need for control of lepidoptera larvae or citrus thrips has been established by written recommendation of a representative of the University of California, Agricultural Extension Service, or a licensed agricultural pest control adviser. The recommendation should state either that the citrus planting does not meet the citrus bloom period criteria, or why alternatives less hazardous to bees would not be effective. The administering agency for the above authority is the CDPR.

5.1.3.3 Local

Local governing bodies may pass ordinances that regulate or restrict pesticide use within their jurisdictional areas. However, these restrictions do not apply to state operations (including those conducted under the authority of the state, specifically CDPH in this case) and would not be applicable to treatments the District proposes under the Program (including those conducted under the authority of the state, specifically CDPH for the District's vector control activities) because California state law preempts local regulation and restriction of pesticide use. However, a school district board can decree that certain pesticides cannot be used in schools under the Healthy Schools Act. The District works collaboratively with schools and school district administration to minimize mosquito and vector production and control populations, when necessary. The District will work with other local entities and property owners to implement BMPs for the protection of public health.

Concerning local ordinances, plans, and policies to protect biological resources including trees, Marin County and its cities (Belvedere, Corte Madera, Fairfax, Larkspur, Mill Valley, Novato, Ross, San Anselmo, San Rafael, Sausalito, and Tiburon) and Sonoma County and its cities (Cloverdale, Cotati, Healdsburg, Petaluma, Rohnert Park, Santa Rosa, Sebastopol, Sonoma, and Windsor) maintain general plans for development and protection of lands within their jurisdictions. The general plans address the protection and enhancement of natural resources including plant, wildlife, and fish habitat and special-status species with broad goals and more specific policies to implement those goals. The discussions below are examples of the local general plan policies and tree ordinances affecting biological resources.

5.1.3.3.1 Marin County General Plan

The County of Marin's Countywide Plan, adopted in 2007 (Marin County 2007a), includes a Natural Systems and Agriculture Element that set county policies "to preserve native habitat and protect natural resources, and sets out programs to restore and enhance ailing habitat." The element describes goals relating to biological resources, water resources, environmental hazards, atmosphere and climate, open space, trails, and agriculture and food. Each of these goals policies and implementing programs are outlined. The goals most pertinent to the District's activities are listed below.

> Section 2.4 Biological Resources:

- BIO-1. Enhanced Native Habitat and Biodiversity. Effectively manage and enhance native habitat, maintain viable native plant and animal populations, and provide for improved biodiversity throughout the County.
- BIO-2. Protection of Sensitive Biological Resources. Require identification of sensitive biological resources and commitment to adequate protection and mitigation, and monitor development trends and resource preservation efforts.
- BIO-3. Wetland Conservation. Require all feasible measures to avoid and minimize potential adverse impacts on existing wetlands and to encourage programs for restoration and enhancement of degraded wetlands.
- BIO-4. Riparian Conservation. Protect and, where possible, restore the natural structure and function of riparian systems.
- BIO-5. Baylands Conservation. Preserve and enhance the diversity of the baylands ecosystem, including tidal marshes and adjacent uplands, seasonal marshes and wetlands, rocky shorelines, lagoons, agricultural lands, and low-lying grasslands overlying historical marshlands.

> Section 2.5 Water Resources.

- WR-2. Clean Water. Ensure that surface and groundwater supplies are sufficiently unpolluted to support local natural communities, the health of the human population, and the viability of agriculture and other commercial uses.

> Section 2.5 Open Space.
  - OS-1. Sustainably Managed Open Space. Manage open space in a sustainable manner for environmental health and the long-term protection of resources.
  - This goal includes Implementing Program OS-1.C. Utilize Integrated Pest Management. Minimize the use of pesticides and herbicides in open-space management. This Program is described below.

Integrated Pest Management Program

The Marin County Board of Supervisors adopted an Integrated Pest Management Ordinance (No. 3521) and IPM policy that governs and guides the control of pests on property the County of Marin owns, manages, and leases. The IPM program uses best practices and science to protect the health of the public and environment, manage their properties, minimize loss due to pests, and reduce pesticide use. The county's IPM is overseen by an IPM Commission (Marin County Parks & Open Space 2010). The IPM Policy outlines the program's purpose and intent, describes its components, and identifies the duties and responsibilities of those implementing the plan (County of Marin 2013).

5.1.3.3.2 Sonoma County General Plan

The Sonoma County Board of Supervisors approved the Sonoma County General Plan 2020 (Sonoma County 2008) on September 23, 2008. This plan provides goals, objectives, and policies that will guide decisions on future growth, development, and conservation of resources through 2020 in a manner consistent with the goals and quality of life desired by the county's residents. The Plan includes the following two elements pertinent to the District's activities: Open Space and Resource Conservation and Water Resources.

The Open Spaces and Resources Conservation Element includes policies addressing the protection of biotic habitats and riparian corridors. It also addresses air quality and energy resources, mineral and timber resources, and soil resources.

> OSRC-7. Protect and enhance the County's natural habitats (special-status species habitat, marshes and wetlands, sensitive natural communities, and habitat connectivity corridors) and diverse plant and animal communities.

> OSRC-8. Protect and enhance Riparian Corridors and functions along streams, balancing the need for agricultural production, urban development, timber and mining operations, and other land uses with the preservation of riparian vegetation, protection of water resources, flood control, bank stabilization, and other riparian functions and values.

> OSRC-9. Protect and conserve the quality of ocean, marine, and estuarine environments for their scenic, economic and environmental values.

The Water Resources Element recognizes the importance of natural vegetation and wildlife habitat, both as beneficial water uses whose needs must be considered but also as factors in maintaining adequate water quality and quantity.

> Goal WR-1. Protect, restore and enhance the quality of surface and groundwater resources to meet the needs of all reasonable beneficial uses.

5.1.3.3.3 Tree Ordinances

The cities and counties may also have ordinances to protect trees. For example, the Marin Countywide Plan, Natural Systems and Agriculture Element (Marin County 2007a) seeks to conserve native woodland habitat. It references the County Native Tree Preservation and Protection Ordinance that was adopted in 1999 to regulate the removal of native trees. The ordinance is intended to regulate sensitive biological resources on the local level by broadening the protection of native tree species not previously addressed by tree protection development standards and the discretionary permit review process, Trees that are

designated as “protected” include a number of species with diameters at breast height of 6 inches. Heritage trees have diameters of 18 inches or more at breast height. If the tree is a “Protected Tree” or “Heritage Tree” and is located in a Stream Conservation Area or a Wetland Conservation Area, then a tree removal permit is required. In Sonoma County, the tree protection ordinance can be found in Section 26-88-010(m) of the Zoning Code (Sonoma County undated). A list of protected tree species can be found in the Section 26-02-140. Per the ordinance “*projects shall be designed to minimize the destruction of protected trees. With development permits, a site plan shall be submitted that depicts the location of all protected trees greater than nine inches (9") and their protected perimeters in areas that will be impacted by the proposed development, such as the building envelopes, access roads, leachfields, etc.*”

5.1.4 Habitat Conservation Plans and Natural Community Conservation Plans

HCPs are planning documents required as part of an application by a nonfederal entity for incidental take of a species listed under the federal Endangered Species Act as part of their proposed activities. An HCP describes the proposed action(s), and its anticipated effects on the individuals and populations of listed species. It also will describe how impacts will be minimized and mitigated. An HCP also can include protections for species that are candidates for listing or are proposed for listing. The HCP is reviewed by USFWS or National Oceanic and Atmospheric Administration (NOAA) Fisheries, when reviewing a project. If a project is approved by the USFWS or NOAA Fisheries, they will issue an incidental take permit for the project actions, which provides for take of these species based on the actions provided for in the HCP, as well as additional measures that the USFWS or NOAA Fisheries might include.

The California Natural Community Conservation Planning Act was first passed by the state legislature in 1991, and was updated and superseded in 2003. The primary objective of the NCCP program is to conserve natural communities at the ecosystem level, while accommodating compatible land use. It focuses on the long-term stability of wildlife and habitat, and seeks to avoid controversy and delays associated with species listings.

CEQA requires that an EIR consider whether a project would conflict with the provisions of an adopted HCP, NCCP, or other approved local, regional, or state habitat conservation plan. Listings of these documents on the USFWS and CDFW websites were reviewed (see Table 4-5), and four approved plans were identified, along with three plans that are currently in development. In addition, one regional plan, the Santa Rosa Plain Conservation Strategy (SRPCS) is also under preparation. Two of these conservation strategies, Turkey Road and SRPCS, lie within the District’s immediate Service Area. The remainder covers portions of the adjoining counties (Mendocino, Lake, Napa, and Solano). These plans are described below.

5.1.4.1 Turkey Road Low Effects HCP

This HCP was prepared by Wildlife Research Associates on behalf of Bradley Jacobs to address the effects of development of a residential property and vineyard on California red-legged frog. The HCP provides measures to minimize and mitigate the adverse effects of the project relating to 0.25 acre of permanent impacts associated with structures and roads, along with temporary disturbance of grasslands during construction, and the development of a 4.5-acre vineyard. Project impacts will be offset through purchase of 0.75 acre of habitat credits in a USFWS-approved mitigation bank.

5.1.4.2 California Department of Corrections Statewide Electrified Fence Project

This HCP was prepared by the California Department of Corrections for their Statewide Electrified Fence Project and addresses mortality or the potential for mortality of special-status species and native migratory birds at 25 prisons where lethal electrified fences are operational and 4 future sites where electrified fences are planned. The HCP provides for take of 62 species covered by the federal Endangered Species Act, California Endangered Species Act, or listed as California Species of Concern, along with an additional 57 species covered under the Migratory Bird Treaty Act, but not included in the preceding category. This

HCP would apply to the Solano State Prison within the District's Adjacent Project Area, although this facility is located in Vacaville, where the District would not be expected to conduct its activities. As the HCP is confined to the prison sites and specifically to mortality due to electrocution of covered species on those fences, this HCP does not apply to the District's activities.

5.1.4.3 Shiloh III

This HCP was prepared by enXco, Inc. to cover the potential impacts of construction of the Shiloh III Wind Project, near Rio Vista, California. The HCP addresses impacts to the central California (Distinct Population Segment (DPS) of California tiger salamander over an area of 4,600 acres for a period of 36 years. The activities covered under the HCP are the construction and installation of wind turbines and associated facilities, maintenance of these facilities, and decommissioning of these facilities in the future. These activities are anticipated to cause both permanent and temporary loss of California tiger salamander habitat. Avoidance and Minimization measures (AMMs) include minimizing impact area; avoiding injury to salamanders during implementation; avoiding erosion and sedimentation impacts to habitat; avoidance of toxic spills; restoration of temporarily disturbed habitat; and ensuring AMMs are implemented. Mitigation is to offset unavoidable permanent impacts at an approved conservation bank. As this HCP is located near Rio Vista, more than 20 miles from the Napa County line, it is unlikely that the District's activities would occur within the boundaries of this HCP.

5.1.4.4 Shiloh IV

This HCP was prepared by Shiloh IV Wind Project, LLC to cover the potential impacts of construction of the Shiloh IV Wind Project, near Rio Vista, California. The project covers impacts to the central California DPS of California tiger salamander over an area of 3,514 acres for a period of 36 years. The activities covered under the HCP are installation and operations of maintenance yards, a substation, wind turbines and associated facilities (including access roads) and decommissioning of these facilities in the future. These activities are anticipated to result in both permanent and temporary loss of California tiger salamander habitat. AMMs include minimizing impact area; avoiding injury to salamanders during implementation; avoiding erosion and sedimentation impacts to habitat; avoidance of toxic spills; restoration of temporarily disturbed habitat; and ensuring AMMs are implemented. Mitigation is to offset unavoidable permanent impacts at an approved conservation bank. As this HCP is located near Rio Vista, more than 20 miles from the Napa County line, it is unlikely that the District's activities would occur within the boundaries of this HCP.

5.1.4.5 Bay Delta Conservation Plan

The BDCP is an HCP being developed as part of California's overall water management portfolio. It is being developed as a 50-year habitat conservation plan with the goals of restoring the Sacramento-San Joaquin River Delta (Delta) ecosystem and securing California water supplies. The plan area encompasses the legal Delta and surrounding areas (Solano, Yolo, Contra Costa, San Joaquin, and Sacramento counties). It does not border Marin or Sonoma Counties, but does encompass parts of adjoining Solano County. The activities covered under the BDCP include improvements to water infrastructure facilities in and around the Delta and the protection of approximately 150,000 acres of habitat to address the Delta's environmental challenges. The BDCP includes 22 conservation measures aimed at improving water operations, protecting water supplies and water quality, and restoring the Delta ecosystem within a stable regulatory framework (BDCP 2014.

The BDCP seeks coverage for 56 species and identifies conservation measures designed to contribute to their protection and recovery. The plan includes 67 goals and 165 objectives that form the basis of the conservation strategy, which includes landscape scale, natural community and biological and species specific goals and objectives. The BDCP also includes 37 AMMs that are incorporated into covered activities to minimize the effects of these actions on various resources. Many of these AMMs focus on minimizing the general environmental effects of construction activities and many others are species specific AMMs.

AMM 33 Mosquito Management calls for management and control of mosquitoes during construction of project facilities. The HCP Implementation Office will accomplish this through consultation with appropriate mosquito and vector control districts and will carry out mosquito control activities as necessary and applicable. The types of mosquito control activities that may be carried out under this AMM include surveillance, biological controls, physical controls, vegetation management, and use of larvicides and adulticides, as necessary.

5.1.4.6 Solano Habitat Conservation Plan

The Solano Habitat Conservation Plan is being developed by the Solano County Water Agency (SCWA) and will cover activities over a plan area of 577,000 acres in Solano County and 8,000 acres in Yolo County. The purpose of the Solano HCP is to (a) promote the conservation of biological diversity and the preservation of endangered species and their habitats consistent with the recognition of private property rights; (b) provide for a healthy economic environment for the citizens, agriculture, and industries; and (c) allow for the ongoing maintenance and operation of public and private facilities in Solano County. The plan is intended to cover activities undertaken by or under the permitting authority/control of the plan participants. Coverage may also be extended to third parties who fall under the direct regulatory control of the plan parties. The plan covers a number of natural communities and 36 covered species (SCWA 2102).

The Solano HCP would set up a reserve system with measurable biological standards to measure the overall success of the HCP conservation program. The plan specifies specific acreages of habitat to be established within the reserve system for different natural habitat types and species. Plan goals and objectives would be accomplished through implementation AMMs and mitigation measures. To obtain coverage under the Solano HCP will require that baseline studies be conducted for any proposed projects, the plan AMMs are implemented, and that the mitigation measures of the plan are carried out, when impacts do occur. AMMs include general measures for operation, maintenance and construction activities; habitat and covered species-specific AMMS; and special management species AMMS, with corresponding mitigation requirements for each covered resource.

5.1.4.7 Mendocino Redwood Company

Mendocino Redwood Company, LLC (MRC) is in the process of developing a HCP with the federal agencies (USFWS and NMFS), a NCCP with the CDFW, and a Program Timberland Environmental Impact Report with the California Department of Forestry and Fire Protection.

Timber management is the primary activity in the plan area, occurring on approximately 213,000 acres. Management activities include timber harvest and regeneration, site preparation, planting, vegetation management, thinning, and fire suppression.

The HCP/NCCP is MRC's operational plan for managing 11 federal or state threatened or endangered wildlife species, 31 rare plants, and 4 sensitive natural communities on the approximately 213,000-acre property located in coastal Mendocino County, California.

The plan, based on the Humboldt Redwood Company, LLC HCP/NCCP, provides for conservation measures for many endangered and threatened species (including spotted owls, marbled murrelets, several salmonid species, rare mammals, amphibians, reptiles, and plants). The HCP requires large riparian buffers designed to provide tree canopy over streams for maintenance of cool water temperatures, filter strip properties, and abundant large wood for protection and enhancement of salmonid habitat. Management of these buffers over time should also increase the amount of old forest characteristics along these streams.

MRC's proposed 80-year term plan provides for the following outcomes: protect, enhance, and increase habitat for rare, threatened, or endangered species covered in the plan; mitigate the impact of land management on covered species; maintain and improve biodiversity in the covered area; contribute to the

recovery of threatened and endangered species, and; attain "regulatory certainty" for endangered species management (MRC 2014.

As this HCP/NCCP is located in Mendocino County adjacent to Sonoma County and within approximately 2 miles of the county border, it is possible that the District's activities could occur within the HCP/NCCP boundaries.

5.1.4.8 Santa Rosa Plain Conservation Strategy (Regional)

The SRPCS is a long-term conservation program sufficient to mitigate potential adverse effects on five listed species (California tiger salamander, Burke's goldfield, Sonoma sunshine, Sebastopol meadowfoam, and many-flowered navarretia) due to future development on the Santa Rosa Plain. The Santa Rosa Plain (Sonoma County) is about 20 miles long (encompassing Windsor and Rohnert Park) and 6 miles wide (extending from Santa Rosa to Sebastopol). The goals are to:

> Develop a habitat conservation strategy that contributes to the recovery of California tiger salamander and listed plant species.

> Identify proposed areas for conservation.

> Develop an implementation framework for the conservation strategy which identifies short and long-term actions and milestones as needed.

> Establish development process predictability.

The strategy identified eight conservation areas, one tiger salamander preserve system, one listed plant preserve system, and one listed plant conservation area. Although local governmental agencies have not yet been able to complete the implementing ordinances for the strategy (USFWS 2013), the strategy is being implemented under the authority of a programmatic biological opinion (USFWS 2007 cited in USFWS 2013) and the oversight of an Implementation Committee, including representatives from local jurisdictions, USFWS, CDFW, and private landowners and the environmental community. Three conservation banks have been approved by the USFWS to date, and they continue to work to approve additional banks. The programmatic biological opinion simplifies the process of consulting with USFWS and complying with the federal Endangered Species Act by using a template in many circumstances, significantly shortening the permitting timeline.

The conservation program will contribute to the recovery of the Sonoma County populations of the five listed species and the conservation of their habitat within the conservation areas described above in a manner that protects stakeholders' (both public and private) land use interests, and supports issuance of an authorization for incidental take of California tiger salamander. Project impacts may be mitigated with the purchase of mitigation credits in one of the USFWS-approved mitigation banks located on the Plain.

5.2 Environmental Impacts and Mitigation Measures

This section identifies the environmental issues and concerns associated with the Program alternatives and presents the significance criteria used to evaluate the likely impacts of the various Program alternatives on terrestrial resources under CEQA. The significance criteria establish thresholds to determine whether an impact rises to a level that is biologically significant. The environmental issues describe the mechanisms by which such impacts might occur.

5.2.1 Evaluation Concerns and Criteria

The Program alternatives are implemented as part of an IVMP as described in Section 2.3. The IVMP uses nonchemical and chemical treatments in a sequential manner to minimize potential environmental impacts, evaluating each treatment site and situation and implementing the least harmful technique that is applicable for that situation consistent with IPM principles. Treatments with higher potential risk to the environment are only implemented when treatments with lower potential risk are ineffective or cannot be

applied to that site. This approach minimizes the overall Program risk to the environment, but environmental concerns relating to the different alternatives remain.

5.2.1.1 Environmental Concerns

The Program alternatives have the potential to affect terrestrial resources directly by affecting physical habitat and through acute or chronic toxicity to special-status species or other nontarget organisms. Habitat alterations such as removal or reduction of habitat and vegetative cover may also indirectly result in impacts to the ranges and abundance of prey animals. Exposure of nontarget organisms to pesticides can result in acute or chronic toxicity, depending on the concentrations encountered. Additionally, indirect exposure may occur via ingestion of contaminated prey animals, bioaccumulation of chemicals, or biotransformation of pesticide active ingredients to different compounds. The Program's potential to affect ecological health through impacts to nontarget ecological receptors is evaluated separately in Section 6.2 with an emphasis there on chemicals used or proposed for use as part of the District's IVMP.

Concerns identified during public scoping include the following, which are addressed as elements of the broader issues explained above:

> Discuss potential impacts on insect pollinators/bees from chemicals in treatment applications.

> Describe the effects of all chemicals that are used and/or proposed for use on wildlife and natural ecosystems, including insect prey, birds, mammals, fish, vegetation and site topography. The loss of prey for birds is a particular concern. Also, consider unwanted effects of the "inactive" portion of the pesticides. What effects will the carrier portion of the chemicals have on the environment?

> Discuss the potential impact of *Bacillus sphaericus* (Bs)/*Bacillus thuringiensis israelensis* (Bti) products on native species.

> Describe the role of mosquitoes within the food chain, and subsequent impacts if they were removed in terms of amphibians, birds, reptiles, fish, and insects. This issue is also addressed in Section 6.2.

> Pesticides can also kill the natural predators of mosquitoes, which can have difficulty in recovery from pesticides.

> Pesticide efficacy attenuation and possible long-term resistance is an issue for all chemically based mosquito control programs. It is addressed by the use of different control methods and different agents over time where possible (BMP and IVM techniques are designed to identify these issues early and modify applications as appropriate and feasible).

> Note that the Program Area includes potential habitat for several California and federally threatened and other sensitive plant and wildlife species and, as such, comprehensive biological studies should be implemented.

> Coordinate with CDFW, CNDDB (CDFW 2012), USFWS, and USFWS' Information, Planning, and Conservation planning tool to identify special-status plant and wildlife species. If impacts are found to be significant, the PEIR should identify adequate mitigation measures to reduce impacts to lower levels.

> A primary concern is the environmental impact on natural resources in terms of vegetation removal, soil erosion, and possible wildlife impact.

> Ensure mosquito abatement staff minimizes impact to tidal marsh and vernal pool habitats (especially during breeding season). Restrict operation of vehicles to levees and existing roads, and avoid vernal pool plants during blooming season (March–June).

> Concern for spread of invasive weeds, erosion, and sedimentation.

> The PEIR should include a detailed description and complete assessment of the surveillance, physical control, biological control, and chemical control impacts (current and future, direct and indirect) on habitats (including endangered, threatened, and locally unique species and sensitive habitats) and on species (sensitive fish, wildlife, or plants).

5.2.1.2 Significance Criteria

Significance criteria were developed based on applicable regulations and management policies, a review of the available information, and the professional judgment of the authors.

The CEQA Guidelines include several criteria for determining whether a potentially significant impact exists to biological resources in the CEQA Appendix G, *Environmental Checklist Form*, Section IV. Those that could apply to the Proposed Program as thresholds of significance for biological resources have been used in the following evaluation with the analysis organized according to these criteria as environmental topics. Impacts were considered potentially significant if they would:

a. Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the CDFW or USFWS.

b. Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations, or by the CDFW or USFWS.

c. Have a substantial adverse effect on federally protected wetlands as defined by CWA Section 404, (including but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means.

d. Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites.

e. Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance.

f. Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan.

5.2.2 Evaluation Methods and Assumptions

5.2.2.1 Evaluation Methods

In general, the methodology for determining impacts under CEQA focuses on types of habitat and special-status terrestrial species, and are evaluated using the criteria described above as environmental topics. Potential impacts were assessed using available information on the types of vector control and treatment as described in Chapter 2, Program Description, and assuming that all applicable BMPs as described in Chapter 2, Table 2-6, (based on *Best Management Practices for Mosquito Control in California* [CDPH and MVCAC 2012] contained in Appendix F), the Statewide General NPDES Permit for Biological and Residual Pesticide Discharges to Waters of the US from Spray Applications (SWRCB Water Quality Order No. 2011-0004-DWQ; NPDES No. CAG 990007; Spray Applications Permit) and District-specific BMPs, as indicated in the PAPs and Aquatic Weed Control Permits (APAPs). The BMPs most applicable to minimizing and/or avoiding impacts to terrestrial resources are repeated in Table 5-3, which also indicates the habitat types in which those BMPs will be applied. This assessment considers the physical and biological connections between treatment areas and terrestrial ecosystems. This information was evaluated in the context of the Program alternatives and the existing environment under baseline conditions in 2012 in the Program Area as described in Section 5.1.1.

The detailed BMPs described in Table 2-6 (and associated with the habitat types they would be applied to in Table 5-3 listed below) can be placed into several categories. These categories include:

1. Agency communication includes periodic discussion with resource agencies, refuge managers and other land managers about topics such as: planning, specific site issues, special-status species occurrence, opportunities for source reduction, observations made by District staff (e.g., wildlife, trespass/unauthorized equipment use) and activities to be implemented. It also includes the District obtaining any required permits and reporting regarding existing permits, periodic check-in calls, and other calls as needed, when unanticipated circumstances arise.
2. Environmental training includes environmental awareness training provided to all field staff regarding environmental resource issues, recognition and documentation of sensitive environmental resources in the field, and BMPs to avoid or minimize impacts to those resources. This category includes both general training, training to avoid or eliminate the spread of weeds, and special-status species or habitat specific training provided to District staff by USFWS, CDFW, or other appropriately trained persons approved by these agencies.
3. Pretreatment screening involves a pretreatment assessment of pesticide treatment locations for environmentally sensitive resources to determine appropriate treatment, access routes, and other BMPs to be applied for that location. This category may include a pretreatment site visit to confirm information used in the screening.
4. Disturbance minimization includes:
    a. avoiding environmentally sensitive areas as much as practical,
    b. using existing access routes where ever possible, whether on foot or in a vehicle
    c. minimizing use of offroad vehicles as much as possible, and driving slowly when they are used
    d. being observant and working carefully to avoid or minimize disturbance
    e. using hand tools rather than mechanized tools as much as practical for all vegetation clearing (including clearing of access ways) or physical control treatments
5. Habitat or species-specific BMPs includes BMPs targeted to a specific habitat type or species (e.g., tidal marshes or salt marsh harvest mouse). These BMPs include measures specific to those habitat types or species including diurnal or seasonal limitations on specific project activities, specific controls on the types of activities or how they are carried out. Specific measures are those documented in Tables 2-6 and 5-3.
6. Alternative-specific BMPs relate specifically to the implementation of a particular treatment (Physical Control, Vegetation Management, Chemical Control). These may overlap many of the BMPs described above, but also include alternative-specific measures to protect environmental resources, based the type of activity to be conducted (e.g., protection of soil surface, minimization of turbidity under the Physical Control Alternative or adherence to label directions, treating only during periods with acceptable weather conditions, and employing appropriate buffers for Chemical Control).

These categories are not inclusive of all the BMPs in Table 5-3, **nor are they intended to replace those more specific BMPs**. These categories are provided to facilitate the discussion of the impact evaluations through the end of this chapter. Table 5-3 lists all of the BMPs for Program implementation by alternative and habitat types that are relevant to biological resources and determinations of impact significance. In practical terms, the District treats terrestrial areas with the same care and sensitivity to plants and wildlife that it does for aquatic and wetland habitats.

Impact determinations follow the analysis for each Program alternative and cover the following issues derived from the CEQA significance criteria (Section 4.2.1.2):

a. Impacts to special-status species

b. Impacts to riparian habitats or other sensitive natural communities

c. Impacts to federally protected wetlands

d. Impacts to movement of native resident or migratory fish or wildlife species.

e. Impacts to local policies

f. Conflicts with provisions of HCP, NCCP, or other approved habitat conservation plan

Impacts are evaluated with regard to desired terrestrial plant and animal (e.g., native and listed species) communities, and effects on food supply for wildlife, using the CEQA criteria described above (Section 5.2.1.2). Potential impacts were assessed using available information on the types of control and treatment and the toxicity of the various chemicals used, the treatment descriptions, and the physical and biological connections between treatment areas and terrestrial ecosystems. This information was evaluated in the context of the Program alternatives and the existing environment under baseline conditions in the Program Area as described in Section 5.1.1. Note that Chapter 6, *Ecological Health*, specifically addresses potential impacts to nontarget ecological receptors but is not focused on terrestrial habitat types.

The potential impacts of the nonchemical alternatives are based on the type and location of habitats treated and the magnitude and frequency of treatment. The potential impacts of the chemical alternatives were evaluated based on the magnitude and duration of the treatments and the toxicity and application information presented in Chapter 6, *Ecological Health*, and Appendix B, *Ecological and Human Health Assessment Report*. The evaluation of all alternatives considered the life histories of the different listed species and ecological interactions, including impacts to the terrestrial food chain.

Pesticides the District uses or proposes to use in the future were investigated to provide a preliminary assessment of the potential impacts to nontarget ecological receptors. Appendix B provides the results of review and evaluations of pesticide (insecticides, herbicides) active ingredients and adjuvants the District currently uses or proposes for use (along with others the District has not selected for use). A comprehensive literature review was conducted to evaluate environmental fate and general toxicity characteristics for the active ingredients and adjuvants. The results of the assessment were used to rank the potential for adverse effects to human health and the environment. Chemical and application characteristics such as the likelihood of exposure for nontarget species and habitats, the potential for drift, and the possible transport and fate of the chemical in various media (i.e., air, surface water/groundwater, soil) were considered in the assessment. Those active ingredients that appear to exhibit either a higher level of risk or have specific use patterns warranting further research are listed in Table 6-5 (in Section 6.2.7).

The pesticide application scenarios that result in reasonable efficacy with minimal unwanted risk are preferred and are the basis of IPM approaches and BMPs the District employs. Each of the pesticides and herbicides identified for further evaluation in Appendix B (as a subset of all pesticides and herbicides in use) is known to exhibit at least one parameter that appears to have an important role in the resulting potential or perceived risk.

5.2.2.2 Assumptions

The following assumptions were used in the assessment of potential terrestrial resource impacts from the Program alternatives:

> Site-specific evaluation of terrestrial resource impacts is not within the scope of this programmatic evaluation. Rather, the analysis uses habitat types likely to be affected by any of the alternatives as the basis for evaluation.

- The programmatic evaluation is based on the current proposed control methods and is subject to change based on future needs (see Section 1.8).
- The BMPs listed in Table 5-3 will be implemented by District staff as appropriate to the type of activity under the Program alternatives.

This terrestrial resources evaluation does not include assumptions about which alternative treatment strategy or strategies would be applied in any given area. Therefore, each Program alternative is considered as a stand-alone option, although the Program may include multiple alternative implementations within a given area (i.e., physical controls followed by larvicide application). Guidelines used to trigger a particular alternative based on mosquito abundance and other variables are included in District-specific operating procedures. This evaluation assumes that important parameters such as sediment half-life are dependent on the specific conditions at the time of pesticide application; therefore, the values listed herein serve as reference values.

This evaluation assumes that all pesticides are applied in accordance with product label instructions and USEPA and CDPR requirements (and in consideration of the local context for that area, i.e., nearby area land uses and habitats). The USEPA requires mandatory statements on pesticide product labels that include directions for use; precautions for avoiding certain dangerous actions; and where, when, and how the pesticide should be applied. This guidance is designed to ensure proper use of the pesticide and prevent unreasonable adverse effects to humans and the environment. All pesticide labels are required to include the name and percentage by weight of each active ingredient in the product/formulation. Toxicity categories for product hazards and appropriate first-aid measures must be properly and prominently displayed. Pesticide labels also outline proper use, storage, and disposal procedures, as well as precautions to protect applicators. The directions for use specify the target organism (pest), appropriate application sites, application rates or dosages, contact times, and required application equipment for the pesticide. Warnings regarding appropriate wind speeds, droplet sizes, or habitats to avoid during application are also prominently displayed.

Concerning the application of multiple chemical treatments in the same area, such as larvicides followed by adulticides (i.e., not likely to occur under normal circumstances), or the application of multiple pesticides at the same time in a specific area (e.g., usually multiple active ingredients in the formulation such as VectoMax which combines Bti and Bs), the following information applies:

> Most products sold as herbicides and pesticides are evaluated herein both for the active ingredient and for the adjuvants and surfactants used to make the product more useful. When multiple products are used in a vector control application, the impacts are weighed against the proximity and timing of each application. If products with similar or even different active ingredients are applied simultaneously, it is likely that the net effect could be the sum of the effects of the active ingredients to impact the vector. However, for vector control applications, materials with the same active ingredient are not applied to the same specific area or simultaneously at a given site. The need for reapplication of mosquito larvicides or adulticides is surveillance driven and performed per the label directions. The District can apply larvicide materials with different active ingredients during a single application. This type of application is necessary if multiple hatches of mosquito larvae occur and results in mosquito populations occurring at different stages of the life cycle. An example is when liquid Bti and methoprene are applied simultaneously. When occurring, the combination of the material is a product called Duplex, and the mixture of the materials and active ingredients is provided for on the product label. Another example for the District includes a pre-application of a liquid trans allethrin and phenothrin spray product that may be used to minimize the hazard of approaching a yellow jacket nest. Situations that would produce a residual exposure adequate to cause harm to humans would not occur unless the application(s) were inappropriate or the

timing of applications is inappropriately close. Actual applications do not generally occur that close together unless a problem with treatment effectiveness arises. A material is applied followed by post-treatment inspection to determine effectiveness. Only if the vectors (mosquitoes) have not been sufficiently killed would the District go back into the area and reapply a pesticide.

Assumptions and/or background information related to the analysis of hazards, toxicity, and exposure for chemical treatment methods are explained below, including the definition of key terms. The concept of ecological food web is explained as well, and it is addressed primarily in Section 6.2.2.2 Assumptions. Background information on bioaccumulation and biomagnification is provided in Section 6.1.1.3, and the analysis or potential for bioaccumulation is covered in Section 6.2.7.

5.2.2.2.1 Hazardous Material

A "hazardous material" is defined in California Health and Safety Code Section 25501 (p): as "any material that, because of its quantity, concentration, or physical or chemical characteristics, poses a significant present or potential hazard to human health and safety or to the environment if released into the workplace or the environment. "Hazardous materials" include, but are not limited to, "hazardous substances, hazardous waste, and any material that a handler or the administering agency has a reasonable basis for believing that it would be injurious to the health and safety of persons or harmful to the environment if released into the workplace or the environment." Any liquid, solid, gas, sludge, synthetic product, or commodity that exhibits characteristics of toxicity, ignitability, corrosiveness, or reactivity has the potential to be considered a "hazardous material."

5.2.2.2.2 Toxicity and Exposure

Toxicology is the study of a compound's potential to elicit an adverse effect in an organism. The toxicity of a compound is dependent upon exposure, including the specific amount of the compound that reaches an organism's tissues (i.e., the dose), the duration of time over which a dose is received, the potency of the chemical for eliciting a toxic effect (i.e., the response), and the sensitivity of the organism receiving the dose of the chemical. Toxicity effects are measured in controlled laboratory tests on a dose/response scale, in which the probability of a toxic response generally increases as the dose increases. Exposure to a compound is necessary for potential toxic effects to occur. However, exposure does not, in itself, imply that toxicity will occur in all circumstances. Thus, toxic and adverse effects can be mitigated by limiting potential exposure to a dose less than the amount that may result in adverse health effects.

The toxicity data included in the tables and charts in this PEIR are generally derived from rigidly controlled laboratory animal studies designed to determine the potential adverse effects of the chemical under several possible routes of exposure. In these studies, the species of interest is exposed to 100 percent chemical at several doses to determine the lowest concentration resulting in a predetermined adverse effect (LOAEL) on numerous selected physiological and behavioral systems. The second component of these tests is to determine the highest concentration of chemical that results in no measurable adverse effect (NOAEL). These two levels are used to describe the potential range of exposures that could result in adverse effects, including the highest dose with no observed effects.

However, these and other coordinated and focused laboratory tests are designed to document the effects of the chemical using a continuous, controlled laboratory exposure that does not realistically reflect the likely patchy exposures typical of the District field application scenarios. As such, the toxicity information generated using laboratory tests (and some limited field tests) are intended as an overview of potential issues that might be associated with maximum direct exposures to develop and recommend guidance for use that should provide maximum exposure levels of applications that are protective of ecological health. These guidelines include numerous "safety margins" in the toxicity calculations that are intended to provide adequate efficacy to target organisms while not adversely impacting humans or nontarget plant

and animal species. In some instances, the regulatory guidance may include additional suggestions for protective application to assure no significant adverse effect on nontarget species and humans.

The regulatory community uses this basic information to provide a relative comparison of the potential for a chemical to result in unwanted adverse effects and this information is reflected in the approved usage labels and MSDSs, in actual practice, the amounts actually applied by the District within the District's Program Area for vector control are substantially less than the amounts used in the toxicity studies. Because of these large inherent safety factors in recommended product application rates, the amount of chemical resulting in demonstrated toxicity in the laboratory is nowhere near the low exposure levels associated with an actual application for vector control. The application concentrations consistent with the labels or MSDSs[5] are designed to be protective of the health of humans and other nontarget species (i.e., low enough to not kill them, weaken them, or cause them to fail to reproduce). Impacts may occur to some nontarget organisms. Although numerous precautions (BMPs) and use of recommended application guidance is intended to provide efficacy without adverse effects to nontarget organisms, misapplication or unexpected weather conditions may still result in effects on some nontarget organisms in the exposure area. This potential impact is ameliorated/mitigated by careful use of BMPs and advance planning by the District.

Although laboratory toxicity testing focuses on tiered concentrations of chemical exposure, the results of these tests produce a series of toxicity estimates of concentrations less than those that produce mortality. Extrapolation of these data is used to generate estimates of chronic toxicity or possible effects of lower doses that may result in sublethal effects such as reproduction or metabolic changes. In reality, these low-dose exposures need to be sustained over longer periods than are relevant to typical application scenarios for vector control including multiple applications in an area such as a wetland.

5.2.2.2.3 Chemistry, Fate, and Transport

The toxicity of a chemical is also affected by various biological, chemical, and physical parameters that affect the behavior of a compound in the environment and its potential toxicity. The chemistry, fate, and transport of a compound must be analyzed to fully estimate potential exposure to a given receptor. The fate and transport of a compound is determined by the physical and chemical properties of the compound itself and the environment in which it is released. Thus, the following characteristics of a compound must be evaluated: its half-life in various environmental media (e.g., sediment, water, air); photolytic half-life; lipid and water solubility; adsorption to sediments and plants; and volatilization. Environmental factors that affect fate and transport processes include temperature, rainfall, wind, sunlight, water turbidity, dissolved oxygen concentrations, and water and soil pH. Information pertaining to these parameters allows evaluation of how compounds may be transported between environmental media (e.g., from sediments to biota), how a compound may be degraded into various breakdown products, and how long a compound or its breakdown products may persist in different environmental media. In general, when a compound or its breakdown products decomposes rapidly in the environment and does not persist for extended periods, then the compound or product poses a lower risk to nontarget species and a lower potential for environmental pollution. Appendix B provides a discussion of the environmental fate of the pesticide active ingredients and other chemicals associated with specific pesticide formulations used in the Vegetation Management and Chemical Control alternatives.

5.2.2.2.4 Ecological Food Webs

While it is important to evaluate the potential adverse impacts of a pesticide application to potentially affected nontarget species, it is neither feasible nor practical to evaluate those potential impacts to a representative food web. An ecological food web is represented in the illustration representing some of the multitude of possible biotic and food uptake interactions in an ecosystem. Each of the possible

[5] Although the MSDS format is referenced in this document, it should be noted that under the international Globally Harmonized System, the MSDS format has been substantially revised and is now largely replaced by standardized Safety Data Sheets (SDSs).

connections between species is also associated with other interactions. These interactions can be the result of higher levels of animal species organization (trophic) or paired interactions between individuals that result in added, positive associations (symbiotic) for both species.

Although ecological food webs could be used to describe the complex system interactions that might be associated with District pesticide application scenarios, it is neither feasible nor practical to evaluate those potential impacts using a food-web approach. The numerous, complex interactions in typical food webs would be subject to substantial uncertainty. Because of these constraints and complexity, it would be neither practical nor productive to attempt to predict food-web interactions for each of the numerous application scenarios the District uses. It is appropriate, however, to use a food-web analysis to identify and consider the first level of potentially adverse effects to nontarget species that might result from a pesticide application. This information is used to assure a minimal impact to nontarget species and is typically a part of the MSDS and Toxicology profiles, providing the basis for the more reasonable, technically feasible approach to consider the possible nontarget impacts prior to use and the compatibility of each proposed pesticide in the overall approach to the typical vector control by the District. Figure 5-2 illustrates the ecological food-web concept.

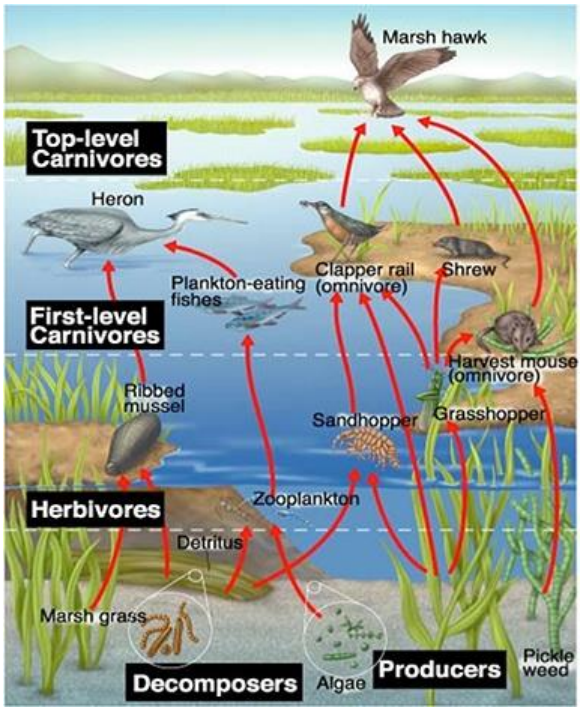


Figure 5-2 Ecological Food-Web Concept

Pesticides can kill natural predators of mosquitoes. The District's activities associated with the Physical Control and Vegetation Management Alternatives would help allow these predators to access habitats where mosquito larvae are present. When chemical control is used to manage mosquitoes, it generally is used at levels that are below the effects thresholds for other insects and invertebrate predators, as described above. Although mosquito pesticides may also affect invertebrate predators (e.g., dragonflies), recovery of predator populations is usually rapid as the predator populations extend beyond the application areas and will rapidly replace any lost individuals. In general, the pesticides used for mosquito control exhibit low or no toxicity to birds or mammals. Limited information is available regarding toxic effects to reptile or terrestrial amphibian mosquito predators.

Mosquitoes are part of the food web and their loss may reduce the food base for some predators. Although mosquitoes serve a role as one of many types of prey items for some fish, avian insectivores, bats, and small reptiles and amphibians, the reduction of mosquito abundance over a small area will not affect the predator populations overall, as other prey sources are available.

5.2.3 Surveillance Alternative

Surveillance activities involve monitoring the abundance of adult and larval mosquitoes, field inspection of mosquito habitat, testing for the presence of antibodies specific to encephalitis virus in domestic and wild fowl, collection and testing of ticks, small rodent trapping and disease testing, and/or response to public service requests regarding vectors such as mosquitoes and yellow jackets.

Mosquito populations are monitored through the use of traps, inspections, and sampling in mosquito habitats. Known and suspected habitats are anywhere that water can collect, be stored, or remain standing for more than a few days, including, but not limited to, catch basins, stormwater detention

systems, residential communities, parks, ornamental ponds, unmaintained swimming pools, seeps, seasonal wetlands, tidal and diked marshes, wastewater ponds, sewer plants, winery waste/agricultural ponds, managed waterfowl ponds, canals, creeks, treeholes, and flooded basements. Ticks are collected along trails and sampled for disease. Rodents (roof rats and Norway rats) may be collected during inspections to respond to public service requests. If preexisting roads and trails are not available to access monitoring sites, low ground pressure ATVs may be used to access these sites. Offroad access is minimized and used only when roads and trails are not available.

5.2.3.1 Impacts to Special-Status Species

Small impacts to upland and wetland habitats in the vicinity of aquatic ecosystems may occur when the District is required to maintain paths and clearings to access surveillance sites and facilitate sampling. These impacts are kept to the minimum amount necessary to minimize potential ingress of predators into these habitats. Such maintenance may include clearing small amounts of vegetation to retain footpaths up to 3 feet wide, or ATV/ARGO paths up to 6 feet wide. However, the vast majority of access routes are via preexisting roads, trails, and walkways, and do not require clearing by the District. Some trails do require periodic trimming or clearing by the District. Occasionally new access routes may be required to assess a vector source. This process will often consist of personnel picking their way through natural openings in the vegetation to the source, but in some cases (i.e., heavy growth of blackberries or poison oak) a trail may need to be created. Where such clearing is required, it is generally done with hand tools. In those rare cases where especially dense vegetation is encountered, a skip loader with mower attachment may be used. No trimming of vegetation greater than 4 inches diameter at breast height would be conducted. Trail maintenance activities would be conducted in the fall, when potential impacts to special-status species would be minimized. However, lighter trail maintenance activities (trimming back small branches or fronds hanging over the access route) may occasionally occur during other times of year. These activities are of small size with limited duration and noise effects, and new access routes would be minimal; therefore, indirect impacts to terrestrial habitats would be inconsequential.

The presence of District personnel implementing the Surveillance Alternative could result in disturbance to special-status species. Such disturbance is most likely to occur during the nesting or breeding season, should the animals abandon suitable habitat as a result of such disturbance including equipment noise. However, these disturbances would be very minor and of short duration, so would likely not cause these animals to abandon the area, but rather move away from the activity while it is occurring. Special-status plants would not be disturbed by the presence of District personnel during surveillance activities.

The Surveillance Alternative may also result in disturbance to species as District personnel are traveling to and from surveillance sites. These access-related impacts would be minimized by adherence to the BMPs indicated in Table 5-3, but in particular those BMPs requiring discussing activities regularly with regulatory agencies or wildlife refuge managers, staying on existing access routes wherever possible, and maintaining and implementing training from USFWS and CDFW personnel regarding special-status species.

In addition, when working in tidal marshes, the District will implement all Tidal Marsh-Specific BMPs, as well as those for salt marsh harvest mouse, Ridgway's rail, and soft bird's beak, where these species are potentially present, as determined through discussion with refuge managers, CDFW, or USFWS personnel. This implementation will include continuing to follow the measures provided in the USFWS' Walking in the Marsh;" employing seasonal and daily activity restriction periods, wherever practical; minimizing travel along tidal channels and sloughs; limiting vegetation removal to the minimum amount necessary; and other BMPs, as indicated in Table 5-3. Through the implementation of these BMPs, substantial impacts to habitat would be avoided, and little to no impact to special-status animals would occur.

Surveillance activities might result in some physical damage to habitat or associated vegetation from foot traffic and vehicle use in areas without marked trails to access areas for potential vector inspection. Special-status species could be directly impacted by these activities. The District investigates sites for the presence of special-status and sensitive species prior to initiating any further surveillance measures in

natural habitat areas, and only small areas would be disrupted briefly by access activities. Most surveillance occurs along access routes that are already established and would only be cleared periodically to maintain access, as necessary. Where new access routes are required they would have only a very small effect on habitat in areas where surveillance occurs. Therefore, minimal impacts would occur to habitat or special-status species.

> **Impact TR-1.** The Surveillance Alternative would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.

5.2.3.2 Impacts to Habitats

Surveillance activities would not affect the quantity or distribution of habitats, such as riparian areas, marshes, lakes or ponds, seasonal wetlands, or other habitat types identified in local or regional plans or listed by CDFW and USFWS. This alternative would not affect the composition of their vegetative communities, as very limited numbers of plants would be pruned or removed over a very small area. Most surveillance occurs along access routes that are already established and would only be cleared periodically, during the fall, to maintain access, as necessary. Surveillance activities might result in some physical damage to habitat or associated vegetation from foot traffic and vehicle use in areas without marked trails to access areas for potential vector inspection. Where new access routes are required, they would have only a very small effect on habitat in areas where surveillance occurs.

The District has long-standing cooperative and collaborative relationships with CDFW, professional biologists and property owners with regard to access, mosquito surveillance and control in association with vernal pools. District staff have received information and training from CDFW and professional biologists with respect to minimizing the potential for impacts to vernal pool habitat and specifically California tiger salamander, Sebastopol meadowfoam, Burke's goldfields, and Sonoma sunshine. When using ATVs to perform mosquito surveillance in the proximity of vernal pools, District staff stay outside of the margin of the vernal pools (delineated by change from wetland to upland vegetation types), and never operate ATVs within wetland vegetation or the actual vernal pool. When possible, District staff performs mosquito surveillance on foot with hand equipment, or by operating ATVs in upland areas a considerable distance from the pools and walking from the ATV to the pools to perform mosquito control (e.g., using a long hose reel based on the ATV). When it is necessary to use an ATV for mosquito surveillance in proximity to vernal pools, the District utilizes low ground pressure vehicles. District staff operates ATVs at slow speeds on sites containing vernal pools, and remains observant while operating equipment and walking in and amongst vernal pool habitat. The District avoids performing mosquito surveillance on rainy days or during dawn and dusk to avoid peak movement periods for California tiger salamander. This alternative would not result in any ground-disturbing activity and, therefore, would not result in any removal, filling, or hydrologic interruption of federally protected wetlands as defined by CWA Section 404 (including, but not limited to, marsh, vernal pool, coastal).

> **Impact TR-2.** The Surveillance Alternative would have a **less-than-significant** impact on riparian habitat or other sensitive natural communities. No mitigation is required.

> **Impact TR-3.** The Surveillance Alternative would have a **less-than-significant** impact on federally protected wetlands as defined by Section 404 of the Clean Water Act. No mitigation is required.

5.2.3.3 Impacts to Migration and Movement

Any disruption of migration patterns would be due to the presence of personnel and vehicles in the environment. In all cases this occurrence would be very short term, generally not more than a few hours in any given location. Therefore, this effect would be minimal, would have no effect on the movement of any native resident or migratory fish or wildlife, and would not affect wildlife migration corridors or nursery areas, as no physical disturbance would occur.

Impact TR-4. The Surveillance Alternative would have **no impact** on the movement of any native resident or migratory fish or wildlife species, nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites.

5.2.3.4 Conflict with Local Ordinances

The county and city general plans and their goals and policies pertaining to natural resources are protective of terrestrial resources and focused on conservation of existing resources including mature trees and important woodland communities. Surveillance activities would not result in the conversion of natural habitats to other land uses or in the long-term or permanent dislocation of plant and animal species from natural areas except indirectly for mosquitoes and vectors of disease and discomfort. Surveillance activities would not affect trees more than 4 inches diameter at breast height and, therefore, would not conflict with local tree ordinances.

Impact TR-5. The Surveillance Alternative would have **no impact** on local policies or ordinances protecting biological resources.

5.2.3.5 Conflict with Conservation Plans

Two conservation plans, Turkey Road and the SRPCS, were identified whose action areas are within the District's primary Service Area. The Turkey Road HCP provides for protection and mitigation of impacts to California red-legged frog associated with residential and vineyard development. The SRPCS provides for the protection and mitigation of impacts to California tiger salamander and four listed plant species from development on the Santa Rosa Plain in Sonoma County.

The District conducts surveillance operations within the area covered by the regional SRPCS. The District regularly communicates with and works collaboratively with the SRPCS Interagency Review Team (IRT), also referred to as the Implementation Committee), and with representatives from agencies such as SWQCB, USEPA, USACE, CDFW, and USFWS. The District receives environmental awareness training from agency staff (e.g., CDFW, USACE) and independent biologists on how to identify the species and their habitats to minimize impacts from accessing monitoring sites within the affected areas. In particular, the District conducts annual field training for field staff regarding precautionary and avoidance measures related to surveillance for mosquitoes in vernal pool habitat. The District uses specialized equipment to access vernal pool habitats.

Six conservation plans affect portions of adjacent counties as identified in Table 4-5. District activities are typically not among those covered by these HCPs. When called into these adjacent counties to perform work, the District would operate under the auspices of that county's mosquito and vector control district and in compliance with their practices and permits, or with the county, if there is no vector control district. The District would operate in compliance with all active HCP/NCCPs. Therefore, the District activities would not be inconsistent with the provisions of any adopted HCP, NCCP, or other approved local, regional, or state-approved conservation plan.

Impact TR-6. The Surveillance Alternative would have a **less-than-significant** impact on adopted HCPs or NCCPs. No mitigation is required.

5.2.4 Physical Control Alternative

The Physical Control Alternative would be a continuation of existing activities using applicable techniques, equipment, vehicles, and watercraft.

Physical control for mosquitoes consists of the management of aquatic areas that provide mosquito-producing habitat (including freshwater marshes and lakes, saltwater marshes, temporary standing water, vernal pools, and wastewater treatment facilities) especially through water control and maintenance or improvement of channels, tide gates, levees, and other water control facilities. For physical control measures used for onsite wastewater treatment systems, see Section 9.2.4.

The District may also advise landowners and homeowners about the importance of dumping/inverting of containers holding water, controlling vegetation against structures, and avoiding stagnant ponds. In situations where any potential exists for sensitive habitats or special-status species to be present, the District includes information and contact data for resource agencies and potential permits.

5.2.4.1 Impacts to Special-Status Species and Habitats

The District would not conduct physical control measures in upland habitat types, but may affect terrestrial species that occur in wetland habitat types. Mosquitoes typically breed in shallow areas, with emergent vegetation, little to no current, and where fish are excluded. This alternative modifies habitats that support mosquito larva to make these habitats less suitable for mosquitoes and/or more suitable for their predators. This alternative includes maintenance of ditches and water control structures, removal of debris and weeds, clearance of brush for access to areas to be treated, and filling of nonfunctional water circulation ditches. It may also include reconnecting backwaters or isolated pools on the floodplains of streams and rivers, and increased drainage rates and areas in managed wetlands. These activities are conducted in accordance with all appropriate environmental regulations. This work in creeks, rivers, ponds, lakes, marshes, and other wetlands may require permits from the USACE, RWQCB, CDFW, USFWS, NOAA Fisheries, and others. Federally protected wetlands are defined by CWA Section 404, (including but not limited to, marsh, vernal pool, coastal, etc.) where adverse effects could occur through direct removal, filling, hydrological interruption, or other means. The Physical Control Alternative would not reduce the quantity of this habitat, but simply improve circulation within the marsh. Only inactive channels would be filled to eliminate ponding. Work would not begin until all required permits are obtained. The potential effects of this alternative on these habitats are described below.

District activities largely involve maintenance of existing facilities in the same manner they do under baseline conditions. The District is rarely involved in new drainage projects, and when they are, they consult with the appropriate agencies and acquire all required permits for implementing that work, which provides protection for native and special-status fish species. The District's annual work plans are submitted for review by other responsible agencies prior to implementation. Completed work is available for inspection by the USACE, USFWS, and CDFW upon request.

Mosquitoes are part of the food web and their loss may reduce the food base for some predators. Although mosquitoes serve a role as one of many types of prey items for some fish, avian insectivores, bats, and small reptiles and amphibians, the reduction of mosquito abundance over a small area will not affect the predator populations overall, as other prey sources are available.

Physical control measures for rodents and nuisance wildlife would be limited to providing advice for restricting ingress of rodents into structures or decreasing habitat for them near residences. This measure would not affect aquatic or terrestrial habitats and would have no effect on aquatic or terrestrial resources. Physical controls are not implemented for yellow jackets or ticks.

5.2.4.1.1 Coniferous Forest

The general lack of surface water in coniferous forests (dominated by cone-bearing trees with needles, which include pines, firs and redwoods, and excluding treeholes) usually does not facilitate the appropriate habitat to support mosquitoes. This habitat does support a variety of special-status species including purple martin, raptors and other avian species (afforded protection under USFWS and CDFW), pallid bat, Sonoma tree vole, western red bat, fisher - West Coast DPS as well as special-status plants such as Pennell's bird's-beak. The Physical Control Alternative would have no impact on special-status species, since this alternative would not occur in this habitat.

5.2.4.1.2 Deciduous Forest

The general lack of standing surface water in deciduous forests (dominated by trees that drop leaves annually including buckeyes, some oaks and maples, and excluding treeholes) usually does not facilitate

the appropriate habitat to support mosquitoes. This habitat does support a variety of special-status species including white-tailed kite and other avian species (afforded protection under USFWS and CDFW), pallid bat, Townsend's big-eared bat, and American badger, as well as special-status plants such as Clara Hunt's milk-vetch, robust spineflower, and Calistoga popcornflower. The Physical Control Alternative would have no impact on special-status species or their habitat, since this alternative would not occur in this habitat.

5.2.4.1.3 Shrublands

The general lack of standing surface water in shrublands (dense to moderate stands of coyote brush, ceanothus, poison oak, sage, sagebrush, chamise and diverse other shrubs with grassy openings) usually does not facilitate the appropriate habitat to support mosquitoes. This habitat does support a variety of special-status species including burrowing owl, Swainson's hawk and other avian species (afforded protection under USFWS and CDFW), pallid bat, Townsend's big-eared bat, western red bat and American badger, as well as special-status plants such as Clara Hunt's milk-vetch, robust spineflower, Vine Hill clarkia, and Pennell's bird's-beak. The Physical Control Alternative would have no impact on special-status species or their habitat, since this alternative would not occur in this habitat.

5.2.4.1.4 Grasslands

The general lack of standing surface water in grasslands (grasslands dominated by annual grasses, with varying amounts of native perennials) usually does not facilitate the appropriate habitat to support mosquitoes. This habitat does support a variety of special-status species including burrowing owl, Swainson's hawk, white-tailed kite, northern harrier, and other avian species (afforded protection under USFWS and CDFW), and American badger, as well as special-status plants such as Clara Hunt's milk-vetch, Sonoma sunshine, Tiburon mariposa-lily, Tiburon paintbrush, and Vine Hill clarkia. The Physical Control Alternative would have no impact on special-status species or their habitat, since this alternative would not occur in this habitat.

5.2.4.1.5 Serpentine

The general lack of standing surface water in serpentine soils (shrublands and grasslands on serpentine soils and rock) usually does not facilitate the appropriate habitat to support mosquitoes. This habitat does support a variety of special-status species including burrowing owl, Swainson's hawk, white-tailed kite, northern harrier, and other avian species (afforded protection under USFWS and CDFW), as well as a number of special-status plants such as Tiburon mariposa-lily, Tiburon paintbrush, and Pennell's bird's-beak. The Physical Control Alternative would have no impact on special-status species or their habitat, since this alternative would not occur in this habitat.

5.2.4.1.6 Coastal Dunes

The general lack of standing surface water in coastal dunes (sandy soils with some active sand movement that supports low stands of diverse native perennials and beach grass) usually does not facilitate the appropriate habitat to support mosquitoes. This habitat does support a variety of special-status species including western snowy plover and other avian species (afforded protection under USFWS and CDFW), and Myrtle's silverspot butterfly as well as special-status plants such as beach layia, robust spineflower, and Tidestrom's lupine. The Physical Control Alternative would have no impact on special-status species or their habitat, since this alternative would not occur in this habitat.

5.2.4.1.7 Treeholes

Standing water in treeholes (cavities in branches and trunks of live trees or snags that may provide habitat for a variety of species) may facilitate the appropriate habitat to support mosquitoes. Treeholes support a variety of special-status species including purple martin and a variety of cavity nesting avian species including owls (afforded protection under USFWS and CDFW), and western red bat, pallid bat

and other bat species. Sometimes an absorbent material (e.g., Broadleaf P-4, a high-performance, long-lasting, hydrophilic polymer) may be used to reduce the quality of the habitats for treehole mosquitoes. This material absorbs the water as the treehole/rot cavity fills with rainwater. Use of this material is limited, as many treeholes are not readily accessible (too high off ground, steep slopes covered in poison oak, etc.). This physical control measure would be used in preference to adulticides. If physical controls are used, the treehole will be examined for potential use by special-status species before treatment is made. Sometimes the District will recommend the landowner/manager consult with an arborist or hire a crew to do this work. With implementation of these measures, the Physical Control Alternative would have a less-than-significant impact on special-status species or their habitat.

5.2.4.1.8 Creeks and Rivers and Riparian Corridors

Because their rapid currents do not provide suitable habitat for mosquitoes, creeks and rivers generally do not support substantial numbers of mosquitoes, although, some mosquitoes can be found in slow eddies and back channels, or in pools isolated on the banks as flows recede. Creeks and rivers and the surrounding riparian forest may support special-status species including northern goshawk, Swainson's hawk, bank swallow, and additional avian species (afforded protection under USFWS and CDFW) and other species including special-status plants, as indicated in Tables 4-3 and 4-4. Accessing the site to complete the work during the avian nesting season would be avoided or minimized by implementation of the BMPs in Table 5-3. Habitat alterations to drain such areas will be avoided to the maximum extent possible due to instream special-status species addressed in Chapter 4. The District does not routinely conduct this type of activity, but it may be required in some circumstances. The potential effects of this alternative would be avoided or minimized through implementation of the BMPs in Table 5-3, including those relating to agency communication, environmental training, and pretreatment screening. Furthermore, BMP G3 requires that all maintenance work will be done at times that minimize adverse impacts to nesting birds, anadromous fish, and other species of concern, in consultation with USFWS, NMFS, and CDFW. Work conducted will, whenever possible, be conducted during approved in water work periods for that habitat, considering the species likely to be present. For example, tidal marsh work will be conducted between September 1 and January 31, where possible and not contraindicated by the presence of other sensitive species. With these BMPs, the effects of this alternative would be less than significant.

5.2.4.1.9 Ponds and Lakes

The freshwater habitats that could be treated include the margin of reservoirs and ponds (including artificial ponds such as golf course ponds or stock ponds with natural bottoms). These areas are generally man-made habitats, but they may support special-status species such as tricolored blackbird and additional avian species (afforded protection under USFWS and CDFW) as well as special-status plants on the margins. This potential effect would be avoided and minimized by the BMPs in Table 5-3 relating to agency communication, environmental training, pretreatment screening (BMP A7), and BMP G3 cited above. With these BMPs, the effects of this alternative would be less than significant.

5.2.4.1.10 Freshwater Marsh/Seeps

Freshwater marsh and seeps may provide ideal habitat for mosquito breeding due to their substantial areas of shallow water, limited circulation and emergent vegetation. These areas may potentially support a number of special-status plants and animals such as Boggs Lake hedge-hyssop, Burke's goldfields, Baker's meadowfoam, pappose tarplant, a number of sedges, American peregrine falcon, California black rail, and others, as indicated in Tables 4-3 and 4-4. Physical control in these areas would have the same potential effects as described for lake and pond habitats and would be avoided or minimized by the BMPs in Table 5-3 relating to agency communication, environmental training, pretreatment screening, and BMP G3 cited above. With these BMPs, the effects of this alternative would be less than significant.

5.2.4.1.11 Seasonal Wetlands (includes Vernal Pools)

The USACE defines wetlands as "*those areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. (33 [Code of Federal Regulations] CFR 328.3(b); 40 CFR 230.3(t))*." For the purposes of this document, seasonal wetlands are areas that are flooded for 1 week or more during the year, generally during the rainy season, but do not retain water through the entire year. Seasonal wetlands may be flooded by increased runoff, rainfall, or unusually high tides. The availability of such habitats has been substantially reduced by human land-use practices and flood control measures. Reducing the frequency or duration with which such habitats are flooded would adversely affect habitat and terrestrial resources. The Physical Control Alternative would not reduce the quantity of this habitat, but simply improve circulation within the marsh. Only inactive channels would be filled to eliminate ponding. All work in wetlands would be subject to additional permitting by the US ACE, CDFW, BCDC, and RWQCB.

Vernal pools[6], a specific type of seasonal wetland, often support a unique assemblage of endemic plant and animal species, many of which have been identified as special-status species by federal and state agencies. Terrestrial species that might occur here include tricolored blackbird, alkali milk-vetch, Sonoma sunshine, Mead's owls-clover, and others as indicated in Tables 4-3 and 4-4.

The District receives environmental awareness training from agency staff (e.g., CDFW, USACE) and independent biologists to minimize impacts and conducts annual field training for field staff regarding precautionary and avoidance measures related to vernal pool habitat. This training addresses California tiger salamander, Sebastopol meadowfoam, Burke's goldfields, and Sonoma sunshine. When using ATVs to perform mosquito control in the proximity of vernal pools, District staff stay outside of the margin of the vernal pools (delineated by vegetation change from wetland to upland), and never operate ATVs within wetland vegetation or the actual vernal pool. When possible, District staff performs mosquito control on foot with hand equipment, or by operating ATVs in upland areas a considerable distance from the pools and walking from the ATV to the pools to perform mosquito control (e.g., using a long hose reel based on the ATV). When it is necessary to use an ATV for mosquito control in proximity to vernal pools, the District utilizes low ground pressure vehicles District staff operates ATVs at slow speeds on sites containing vernal pools, and remains observant while operating equipment and walking in and amongst vernal pool habitat. The District avoids performing mosquito control on rainy days or during dawn and dusk to avoid peak movement periods for California tiger salamander. Other specialized equipment that may be used to minimize impacts in vernal pools and other sensitive areas may include mist blowers/granulators, and extended reach spray systems/hose reels and aircraft if feasible.

Because of the sensitive nature of seasonal wetland habitat types, the District generally would not undertake physical control measures in these areas. In the event that physical control in seasonal wetlands or vernal pools was required, the District would not implement water management and vegetation removal actions without previously discussing them with the relevant regulatory agencies or refuge wildlife managers to verify that no other alternative or option is preferable to control the mosquito problem at that location and to make sure that any such activity would be done in such a way as to minimize its impacts. As a result, this "consultation prior to implementation" BMP and the practices described above would result in a less-than-significant impact to terrestrial resources.

[6] ''Vernal pool,'' whether by transfer or by independent invention, is now applied to small wetlands that are present primarily or exclusively in the early part of the growing season and that typically ''dry'' completely or ''substantially'' at some point during the growing season. (http://users.ipfw.edu/isiorho/wetvernalisolatedwetlands2003.pdf)

5.2.4.1.12 Lagoon

Lagoons, located at the mouths of creeks or rivers where they enter the ocean or bay, but isolated from the receiving waterbody by a berm, are indirectly influenced by the tide, which may cause freshwater to back up within the lagoon, and may also allow water to percolate through the berm, with the direction of such movement depending on water levels on either side of the berm. As a result, lagoons often contain a lens of freshwater at the surface and brackish water at the bottom. Thus, lagoons may support species from both creeks and rivers, and from the receiving waterbodies. Lagoons are an important feeding area for special-status birds including bald eagles. Lagoons would support mosquitoes in areas of reduced circulation, often associated with emergent vegetation. Physical control in lagoons would include reconnecting isolated areas to the main lagoon. The BMPs in Table 5-3, in particular BMP G3, will be applied to avoid or minimize impacts to environmental resources. With implementation of these BMPs, the impact of the Physical Control Alternative on resources within the lagoon would be less than significant.

5.2.4.1.13 Tidal Marsh and Channels

Tidal marsh and tidal channel habitats occur along the margins of San Francisco, San Pablo, and Suisun bays and are subject to tidal action. They are typically bounded by levees and water control structures. The San Francisco Bay-Delta once supported vast tracts of freshwater, brackish, and saline marsh habitat. The vast majority of these marsh habitats have been converted to human uses such as farming, industrial uses, and urban development. Some of the remaining marsh lands are maintained and operated to provide habitat for wildlife or as private or public duck clubs. Several examples of these types of habitats occur along the Highway 37 corridor and along Highways 29 and 101 in close proximity to the cities of American Canyon, Napa, Sonoma, Petaluma, and Novato. These wetlands can be important sources of mosquitoes seasonally. These marshes are seasonally flooded and drained to optimize habitat for ducks, geese, and other wildlife.

Physical measures to control mosquitoes in these areas include maintenance of ditches and water control structures, removal of debris and weeds, clearance of brush for access to areas to be treated, and filling of nonfunctional water circulation ditches, as described in Section 2.3.2. Other measures include retaining water on the surface of the area, and rotational impoundment monitoring, which reduces mosquito populations by increasing the frequency with which suitable habitats are inundated and drained. The District advises the landowner and property managers that these actions may require discussion with CDFW, USACE, BCDC, NOAA Fisheries, or the USFWS and that these agencies should be contacted before work is initiated.

These physical control activities would be subject to the BMPs described in Table 5-3, relating to agency communication, environmental training, and pretreatment screening. The Tidal Marsh-Specific BMPs will also be employed including conducting this work during appropriate seasons and times of day (when the tide is out and when Ridgway's rail, California black rail, San Pablo song sparrow, saltmarsh common yellow throat and salt marsh harvest mouse as well as other special-status species are not nesting), making sure staff have appropriate training when working in the marsh, and minimizing the use of mechanical equipment where practical. Tidal marshes may support a number of special-status plants, including pappose tarplant, soft bird's beak, and others (Table 4-3), and animals, including salt-marsh harvest mouse, Suisun shrew, Ridgway's rail, northern harrier, tricolored blackbird, and other passerine species (Table 4-4). Channels that have substantial tidal flow and inundation would not support mosquitoes and, thus, would not need to be maintained. The disturbance associated with the Physical Control Alternative would be short term and temporary; and with the implementation of the BMPs described above, physical control activities would not substantially affect special-status species.

5.2.4.1.14 Water and Wastewater Treatment Facilities

Wastewater treatment facilities may provide nesting habitat for special-status avian species such as northern harrier hawk since such facilities may lie close to suitable habitats in streams or the San Francisco Bay Delta system. The extent to which these species may enter these facilities is unknown. Because of the limited number of such facilities, the limited use of such facilities by special-status species, and the application of the BMPs described in Table 5-3, physical control measures are not anticipated to substantially affect avian species. Maintenance activities could result in the short term disturbance of special-status animals due to human presence and the noise associated with the activity. This disturbance is only anticipated to last a few hours. Animals may move away from the disturbance while it was ongoing, but to return to the area shortly after the activity ceases. Such work would be conducted outside of bird nesting season, wherever practical. If work needed to be done during the nesting season, nest surveys would be conducted prior to initiating work, and suitable buffers would be established around any active nests while performing the work.

Septic/onsite wastewater treatment systems with their associated leach fields may provide habitat for special-status avian species associated with riparian and emergent vegetation, such as song sparrows, yellow-breasted chat, yellow billed-cuckoo, and other passerine birds as indicated in Table 4-4, under freshwater marsh/seeps and riparian forest, although their presence would be dependent on suitable vegetation and other habitat conditions, generally not associated with septic systems.

Winery waste ponds generally contain waste from grape pressings and washwater from cleaning winery equipment. These ponds generally do not provide suitable habitat for special-status species, as they are highly managed and often suffer from low water quality. The Sonoma County Permit and Resource Management Department, Marin County Environmental Health Department, and, in some cases, the RWQCB controls the management of these ponds. The two county local permitting agencies deal with flows of up to 10,000 gallons per day and with subsurface disposal only. If the daily flow exceeds this value or surface disposal is used, then the RWQCB is the controlling agency. The District provides input relating to controlling mosquitoes and other vectors associated with the ponds and winery operations. Physical control is not typically undertaken in winery waste ponds, although it is possible that it could be required under unusual circumstances. Because of the poor quality habitat provided and because physical control activities would rarely be conducted in these waste ponds, little likelihood of impacts to special-status species exists.

Flood control channels and ditches may support special-status species where they have suitable physical and vegetative structure. Physical management activities would be designed to reduce ponding of water within these areas. The application of the BMPs in Table 5-3, particularly those pertaining to agency communication, pretreatment screening, and environmental training, will avoid impacts to any special-status species that might occur in these habitats.

5.2.4.1.15 Artificial Containers, Temporary Standing Waters and Ornamental Ponds

Artificial containers do not provide habitat for special-status terrestrial species, i.e., those identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the CDFW or USFWS. Thus, physical control of artificial containers (ensuring that these containers do not hold water for a sufficient period to support mosquito larvae) would have no impact on these species or their habitat.

Temporary standing waters refers to water ponding on an upland habitat because of rainfall or irrigation. Ornamental ponds are small ponds with artificial bottoms. These habitats do not provide habitat for special-status aquatic or terrestrial species.

5.2.4.1.16 Impact Determinations for Special-Status Species and Habitats

Impact TR-7. The Physical Control Alternative, would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.

Impact TR-8. The Physical Control Alternative, would have a **less-than-significant** impact on any riparian habitat or other sensitive natural community. No mitigation is required.

Impact TR-9. The Physical Control Alternative would have a **less-than-significant** impact on federally protected wetlands as defined by CWA Section 404. No mitigation is required.

5.2.4.2 Effects on Movement and Migration

Physical changes in habitat are unlikely to affect wildlife migration due to the restricted areas within which physical control activities would occur. Additional disruption of migration patterns may occur due to the presence of personnel and equipment in the environment. In all cases this occurrence would be short term, generally not more than a few days in any given location and, therefore, this effect would be minimal and would have little effect on the movement of wildlife.

Impact TR-10. The Physical Control Alternative would have a **less-than-significant** impact on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites. No mitigation is required.

5.2.4.3 Conflict with Local Ordinances

The county and city general plans and their goals pertaining to natural resources are protective of terrestrial resources and focused on conservation of existing resources including mature trees and important woodland communities. Physical control activities would not result in the conversion of natural habitats to other land uses or in the long-term or permanent dislocation of plant and animal species from natural areas except for mosquitoes and vectors of disease and discomfort. The Physical Control Alternative would not affect trees more than 4 inches diameter breast height and, therefore, would not conflict with local tree ordinances.

Impact TR-11. The Physical Control Alternative would have **no impact** on local policies or ordinances protecting terrestrial resources.

5.2.4.4 Conflict with Conservation Plans

Two conservation plans, Turkey Road and the SRPCS, were identified whose action areas are within the District's primary Service Area. The Turkey Road HCP provides for protection and mitigation of impacts to California red-legged frog associated with residential and vineyard development. The SRPCS provides for the protection and mitigation of impacts to California tiger salamander and four listed plant species from development on the Santa Rosa Plain.

The District's physical control work in the Santa Rosa Plain is infrequent and minimal. Work is not associated with vernal pools, rather the work is typically in conjunction with wastewater management irrigation (e.g., City of Santa Rosa) or with physical control in waste ponds (e.g., dairy).

The District regularly communicates with and works collaboratively with the SRPCS IRT and with representatives from agencies such as SWQCB, USEPA, USACE, CDFW, and USFWS. The District receives training from agency staff (e.g., CDFW, USACE) and independent biologists to minimize impacts and conducts annual field training for field staff regarding precautionary and avoidance measures related to vernal pool habitat and other seasonal wetland and wetland habitats. While District activities may occur within the boundaries of conservation areas, these activities are coordinated with the plan managers and

would not conflict with the provisions of any adopted HCP, NCCP, or other approved local, regional, or state habitat conservation plan.

Six conservation plans affect portions of adjacent counties as identified in Table 4-5. District activities are typically not among those covered by these HCPs. When called into these adjacent counties to perform work, the District would work collaboratively with that county or its' mosquito and vector control district and in compliance with their practices and permits, including compliance with adopted HCP/NCCPs. Therefore, the District activities would not be inconsistent with the provisions of any adopted HCP, NCCP, or other approved local, regional, or state-approved conservation plan.

> **Impact TR-12**. The Physical Control Alternative would have a **less-than-significant** impact on adopted HCPs or NCCPs. No mitigation is required.

5.2.5 Vegetation Management Alternative

Vegetation management involves the trimming or removal of vegetation to improve access, and to improve water circulation to areas that support mosquito breeding and improve access to natural predators, so that chemical treatments are not required. All such work is done in coordination with the landowner or land manager and the resource agencies, as required. Permits are generally required for this type of activity, and this work would only be initiated after all necessary permits are obtained. All areas are prescreened to determine the potential presence of special-status species and to develop appropriate measures to avoid or minimize effects to these species.

The District preferentially uses physical control for vegetation management and rarely uses herbicides and adjuvants for vegetation management in natural environments. The District may use herbicides in artificial environments, winery waste ponds, wastewater treatment ponds, agricultural ditches. Whenever herbicides are used, they are applied in compliance with label requirements.

Vegetation management in upland habitats would be restricted to providing access to areas to treatment areas though patches of dense vegetation, or in those rare cases when larger equipment is needed for physical vegetation removal.

For projects that result in materials (including plant materials, soils or sediments, or herbicides) entering the water or occur in sensitive wetland habitat, permits may be required from the USACE, RWQCB, CDFW, USFWS, NOAA Fisheries, and others. Work would not begin until all required permits are obtained. The District may also perform vegetation management to assist other agencies and landowners with the management of invasive/nonnative vegetation. These actions are typically performed under the direction of the concerned agency, which also maintains any required permits.

5.2.5.1 Physical Vegetation Removal

Nonherbicide or physical vegetation removal actions may involve reducing standing vegetation using equipment. The use of weed-whackers, small chainsaws, pruners, or shovels may lead to physical injury of terrestrial plants and animals in the treatment area. Manual removal is the primary method of vegetation removal and would not be anticipated to affect substantial patches of vegetation in the affected area. Skid steers are typically used at a small number of sites to mow access paths in dense stands of cattails in seasonal wetlands and retention basins and, infrequently, in riparian habitat to mow access paths through dense stands of blackberry and poison oak to facilitate surveillance and the application of larvicides. This work is typically done in the fall to minimize potential impacts to special-status species by avoiding the breeding season for birds and other species. The District will ensure that all required permits are in place before vegetation management activities are undertaken. Short-term (a few days to a week) increases in noise could result from the operation of heavy equipment under this alternative. The District is in communication with resource agencies prior to performing this type of work. The District applies BMP numbers F1 through F11, as well as many other BMPs, from Table 5-3 to reduce these impacts by (1) identifying sensitive species locations, if any, in the treatment area prior to commencing any

vegetation removal actions, and (2) limiting the extent of heavy equipment use to minimize the area affected (Section 2.9.2). If work is being conducted in tidal marshes, the BMPs specific to tidal marshes (B1 through B6), and those for salt marsh harvest mouse (C1 through C8), Ridgway's rail, and soft birds' beak (E1 through E4) would also be implemented. The potential impact on wildlife would be minimal, as the animals would return to their selected habitats within a few hours after the cessation of the noise sources for most of the physical application techniques the District currently uses.

5.2.5.2 Herbicides and Adjuvants

The District chooses to use physical removal of vegetation whenever possible, but rarely may need to use herbicides to control vegetation in and around mosquito-breeding habitats to improve surveillance and reduce suitable mosquito habitats. The herbicides the District would potentially use are discussed in detail in Appendix B and are listed in Table 2-1 with the active ingredients listed in Table 5-4.

Table 5-4 Herbicide Control Options for Vegetation Management

Active Ingredient	Appendix B
Imazapyr	Section 4.6.1
Glyphosate	Section 4.6.2
Triclopyr	Section 4.6.3

Herbicides included in the Program have diverse chemical structures, act through distinct modes of action, and exhibit varying levels of potential toxicity to humans and nontarget species. Certain herbicides are nonselective and broad-spectrum (e.g., imazapyr) and generally function by inhibiting growth. Herbicides used against annual broadleaf weeds are generally of the post-emergent variety, such as triclopyr. In addition, imazapyr, is a systematic, nonselective, pre- and post-emergent herbicide used for a broad range of terrestrial and aquatic weeds. Glyphosate represents a commonly used herbicide for the control and elimination of grass weeds and sedges. Most of the herbicides are moderately persistent in soil and water (for each herbicide's half-life in soil and water, please refer to Appendix B).

Almost all of the herbicides the District would use exhibit low or no toxicity to mammals, birds, and terrestrial invertebrates. For detailed toxicity information, see Appendix B. In addition, BMPs are applied to minimize the impact of herbicide use on nontarget terrestrial plants, including special-status plants. In particular, the District takes action to minimize drift of herbicides to nontarget areas by carefully considering weather variables such as wind velocity and direction and chance of precipitation. See BMPs H1 through H13 in Table 5-3. See Section 6.2.5 for further analysis of the herbicides and adjuvants that could be used on a limited basis for vegetation management.

The herbicide glyphosate was identified for further evaluation in Appendix B and is discussed further below and in detail in Section 6.2.5.1.1.

The District may use glyphosate on occasion for site access. Although some recent concerns have been expressed about possible sublethal effects of glyphosate products (e.g., endocrine disruption in humans, see Section 7.2.5.1.), it is virtually nontoxic to mammals and practically nontoxic to birds, fish, and invertebrates on an acute basis. Claims that glyphosate is destroying bee and butterfly populations have not been substantiated. The use of glyphosate to control milkweed, which is a severe problem for farmers, but a host plant for some species of butterfly, may be connected to loss of foraging vegetation and, thereby, indirectly impacting butterfly populations. However, this effect is an indirect effect and glyphosate is not actually toxicity to the butterflies. With BMPs and targeted application techniques, glyphosate can be used safely when an adequate buffer (>15 feet) to water sources is maintained or when a formulation specifically designed for use in aquatic environments (Aquamaster) is used. In terrestrial systems, glyphosate is immobile and breaks down relatively quickly via microbial processes. When herbicide application BMPs

(including BMP H12) are applied, the potential impact of glyphosate on special-status species or other nontarget plants is greatly reduced. These BMPs include using targeted, small-scale treatments and taking actions to minimize drift and runoff post-application. Every effort is also made to minimize treatments that could affect milkweed, a plant important to Monarch butterfly populations

An adjuvant is any compound that is added to an herbicide (or pesticide) formulation or tank mix to facilitate the mixing, application, or effectiveness of that herbicide. Adjuvants can either enhance activity of an herbicide's active ingredient (activator adjuvant) or offset any problems associated with spray application, such as adverse water quality or wind (special purpose or utility modifiers). Activator adjuvants include surfactants, wetting agents, sticker-spreaders, and penetrants. The environmental fate and toxicity of adjuvants the District may use are described in detail in Appendix B and listed in Table 5-5. A subset of the adjuvants available for District use was identified for further examination based upon historical use patterns and toxicity (Appendix B, Table 1-1).

Table 5-5 Adjuvants for Insect/Weed Abatement

Active Ingredient	Appendix B
APEs	Section 4.7.1
Modified Plant Oil and Methylated Seed Oil	Section 4.7.3
Lecithin (phosphatidylcholine)	Section 4.7.4
Aliphatic Polycarboxylate	Not included

Alkylphenol ethoxylates (APEs) include a broad range of chemicals that tend to bind strongly to particulates and persist in sediments. Current information about APEs is based on FDA evaluations; regardless, USEPA has speculated that they may pose risk to nontarget terrestrial organisms (USEPA 2010). However, this speculation has not be substantiated and given the limited use of herbicides by the District, in general, and their application of BMPs when using herbicides, the District's use of herbicides with APEs would not be expected to cause any substantive harm to the environment.

Modified plant oils and methylated seed oils are essentially nontoxic to most organisms, including plants. Although toxicity and environmental fate information for these oils is scarce, using current BMP application techniques to reduce the transfer of oils and APEs to nontarget areas post-application (i.e., targeted applications) and based on their other approved uses, these products should not result in unwanted adverse effects to nontarget terrestrial organisms.

Lecithins are naturally occurring phospholipids in biological cell membranes (Bakke 2007). Although toxicity and environmental fate information for these products is limited, using BMP application practices including application at the lowest effective concentration for a specific set of vectors and environmental conditions, use of lecithins should not result in unwanted adverse effects to nontarget terrestrial organisms.

Aliphatic polycarboxlyates are another category of adjuvants that are essentially nontoxic to biota and are used as an additive to enhance the efficacy of several other products. They are listed as having no known toxicity or adverse biological impacts as a polymer additive with no hazard indications in any of the typical categories regulators use to define toxicity. (Kegley et al. 2014)

5.2.5.3 Impacts to Special-Status Species and Habitats

The District would conduct very limited vegetation management measures in upland habitat types. This would be associated with providing access to mosquito habitats for surveillance or treatment. Vegetation management activities may affect terrestrial species that occur in wetland habitat types. This work in creeks, rivers, ponds, lakes, marshes, and other wetlands may require permits from the USACE, RWQCB, CDFW,

USFWS, NOAA Fisheries, and others. Work would not begin until all required permits are obtained. The potential effects of this alternative on these habitats are described below.

Mosquitoes are part of the food web and their loss may reduce the food base for some predators. Although mosquitoes serve a role as one of many types of prey items for some fish, avian insectivores, bats, and small reptiles and amphibians, the reduction of mosquito abundance over a small area will not affect the predator populations overall, as other prey sources are available.

5.2.5.3.1 Coniferous Forest

The general lack of surface water in coniferous forests (dominated by cone-bearing trees with needles, which include pines, firs and redwoods) usually does not facilitate the appropriate habitat to support mosquitoes and, therefore, vegetation management would not be conducted in this habitat. However, access routes may be needed through this habitat to reach areas that do support mosquito breeding habitat. This access would generally be via existing access routes, but may require some vegetation removal along the route. This habitat does support a variety of special-status species including purple martin, raptors and other avian species (afforded protection under USFWS and CDFW), pallid bat, Sonoma tree vole, western red bat, fisher - West Coast DPS as well as special-status plants such as Pennell's bird's-beak. This access activity would be done in coordination with landowners or land managers and resource agencies, as well as following the BMPs described in Table 5-3 relating to environmental training, pretreatment screening, disturbance minimization, avian nesting season, habitat and species-specific BMPs, and applicable vegetation management-specific BMPs (F1 through F11). This activity would result in less-than-significant impacts to special-status species associated with coniferous forest habitat from the Vegetation Management Alternative.

5.2.5.3.2 Deciduous Forest

The general lack of standing surface water in deciduous forests (dominated by trees that drop leaves annually including buckeyes, some oaks and maples) usually does not facilitate the appropriate habitat to support mosquitoes and, therefore, vegetation management activity would not be conducted in this habitat. However, access routes may be needed through this habitat to reach areas that do support mosquito breeding habitat. This access would generally be via existing access routes, but may require some vegetation removal along the route. This habitat does support a variety of special-status species including white-tailed kite and other avian species), pallid bat, Townsend's big-eared bat, American badger as well as special-status plants such as Clara Hunt's milk-vetch, robust spineflower, and Calistoga popcornflower. This access activity would be done in coordination with landowners or land managers and resource agencies, as well as following the BMPs described in Table 5-3 relating to environmental training, pretreatment screening, disturbance minimization, avian nesting season, habitat and species-specific BMPs, and vegetation management-specific BMPs. This activity would result in less-than-significant impacts to special-status species associated with deciduous forest from the Vegetation Management Alternative.

5.2.5.3.3 Shrublands

The general lack of standing surface water in shrublands (dense to moderate stands of coyote brush, ceanothus, poison oak, sage, sagebrush, chamise and diverse other shrubs with grassy openings) usually does not facilitate the appropriate habitat to support mosquitoes and, therefore, vegetation management would not be conducted in this habitat. However, access routes may be needed through this habitat to reach areas that do support mosquito breeding habitat. This access would generally be via existing access routes, but may require some vegetation removal along the route. This habitat does support a variety of special-status species including burrowing owl, Swainson’s hawk and other avian species (afforded protection under USFWS and CDFW), pallid bat, Townsend's big-eared bat, western red bat and American badger as well as special-status plants such as Clara Hunt's milk-vetch, robust spineflower, Vine Hill clarkia, and Pennell’s bird’s-beak. This access activity would be done in coordination with landowners or land managers and

resource agencies, as well as following the BMPs described in Table 5-3 relating to environmental training, pretreatment screening, disturbance minimization, avian nesting season, habitat and species-specific BMPs, and vegetation management-specific BMPs. This activity would result in less-than-significant impacts to special-status species associated with shrublands habitat from the Vegetation Management Alternative.

5.2.5.3.4 Grasslands

The general lack of standing surface water in grasslands (grasslands dominated by annual grasses, with varying amounts of native perennials) usually does not facilitate the appropriate habitat to support mosquitoes and, therefore, vegetation management would not be conducted in this habitat. However, access routes may be needed through this habitat to reach areas that do support mosquito breeding habitat. This access would generally be via existing access routes, but may require some vegetation removal along the route. This habitat does support a variety of special-status species including burrowing owl, Swainson's hawk, white-tailed kite, northern harrier, and other avian species (afforded protection under USFWS and CDFW), and American badger as well as special-status plants such as Clara Hunt's milk-vetch, Sonoma sunshine, Tiburon mariposa-lily, Tiburon paintbrush, and Vine Hill clarkia. This access activity would be done in coordination with landowners or land managers and resource agencies, as well as following the BMPs described in Table 5-3 relating to environmental training, pretreatment screening, disturbance minimization, avian nesting season, habitat and species-specific BMPs, and vegetation management-specific BMPs. This activity would result in less-than-significant impacts to special-status species associated with grassland habitat from the Vegetation Management Alternative.

5.2.5.3.5 Serpentine

The general lack of standing surface water in serpentine soils (shrublands and grasslands on serpentine soils and rock) usually does not facilitate the appropriate habitat to support mosquitoes and, therefore, vegetation management would not be conducted in this habitat. However, access routes may be needed through this habitat to reach areas that do support mosquito breeding habitat. This access would generally be via existing access routes, but may require some vegetation removal along the route. This habitat does support a variety of special-status species including burrowing owl, Swainson's hawk, white-tailed kite, northern harrier, and other avian species (afforded protection under USFWS and CDFW), as well as an abundance of special-status plants such as Tiburon mariposa-lily, Tiburon paintbrush and Pennell's bird's-beak. This access activity would be done in coordination with landowners or land managers and resource agencies, as well as following the BMPs described in Table 5-3 relating to environmental training, pretreatment screening, disturbance minimization, avian nesting season, habitat and species-specific BMPs, and vegetation management-specific BMPs. This activity would result in less-than-significant impacts to special-status species associated with serpentine soils and outcroppings habitat from the Vegetation Management Alternative.

5.2.5.3.6 Coastal Dunes

The general lack of standing surface water in coastal dunes (sandy soils with some active sand movement that supports low stands of diverse native perennials and beach grass) usually does not facilitate the appropriate habitat to support mosquitoes and, therefore, vegetation management would not be conducted in this habitat. However, access routes may be needed through this habitat to reach areas that do support mosquito breeding habitat. This access would generally be via existing access routes, but may require some vegetation removal along the route. This habitat does support a variety of special-status species including western snowy plover and other avian species (afforded protection under USFWS and CDFW), and Myrtle's silverspot butterfly as well as special-status plants such as beach layia, robust spineflower, and Tidestrom's lupine. This activity would be done in coordination with landowners or land managers and resource agencies, as well as following the BMPs described in Table 5-3 relating to environmental training, pretreatment screening, disturbance minimization, avian nesting season, habitat and species-specific BMPs, and vegetation management-specific BMPs. This activity would result in less-

than-significant impacts to special-status species associated with coastal dunes habitat from the vegetation management alternative.

5.2.5.3.7 Treeholes

Vegetation management activities would not be conducted in treehole habitat nor would vegetation management be used to access such habitats. Therefore, no impacts would occur to special-status species associated with treeholes from the Vegetation Management Alternative.

5.2.5.3.8 Creeks and Rivers and Riparian Corridors

Because their rapid currents do not provide suitable habitat for mosquitoes, creeks and rivers generally do not support substantial numbers of mosquitoes, although, some mosquitoes can be found in slow eddies and back channels, or in pools isolated on the banks as flows recede. Creeks and rivers and the surrounding riparian forest may support special-status terrestrial species including northern goshawk, Swainson's hawk, bank swallow, and additional avian species (afforded protection under USFWS and CDFW) and other species including special-status plants, as indicated in Tables 4-3 and 4-4. Vegetation that requires management would typically be confined to channel margins and backwaters with slow currents. This management activity would be done in coordination with landowners or land managers and resource agencies, as well as following the BMPs described in Table 5-3 relating to environmental training, pretreatment screening, disturbance minimization, avian nesting season, habitat and species-specific BMPs, and vegetation management-specific BMPs. This activity would result in less-than-significant impacts to special-status species associated with creeks, rivers, streams and the associated riparian forests.

5.2.5.3.9 Ponds and Lakes

The freshwater habitats that could be treated include the margin of reservoirs and ponds (including artificial ponds such as golf course ponds or stock ponds with natural bottoms). These areas are generally man-made habitats, and they may support special-status terrestrial species such as tricolored blackbird and additional avian species (afforded protection under USFWS and CDFW), as well as special-status plants on the margins.

Vegetation management would be limited in this habitat type, except in smaller ponds, as the depth and size of these areas would typically preclude emergent vegetation from exceeding 30 percent of the surface area. Where necessary, vegetation management activities would be implemented in stagnant areas along the edges of these habitats where mosquito eggs and larvae occur. Special-status avian species would likely not be impacted in reservoirs and ponds, as vegetation removal in these habitats is minimal. Special-status plants would likely not be present in lakes or ponds but may be present along the margins. Vegetation management could directly affect these plant species but substantial areas of similar habitat would remain undisturbed.

This potential impact would be avoided and/or minimized by the BMPs in Table 5-3 relating to agency communication, environmental training, and pretreatment screening. Vegetation management-specific BMPs will be applied. Furthermore, work conducted will, whenever possible, be conducted during approved in water work periods for that habitat, considering the species likely to be present. With these BMPs, the effects of vegetation management would be less than significant.

5.2.5.3.10 Freshwater Marsh/Seeps

Freshwater marsh and seeps may provide ideal habitat for mosquito breeding due to their substantial areas of shallow water, limited circulation and emergent vegetation. These areas may potentially support a number of special-status terrestrial plants and animals as indicated in Tables 4-3 and 4-4, such as Boggs Lake hedge-hyssop, Burke's goldfields, Baker's meadowfoam, pappose tarplant, a number of sedges, American peregrine falcon, California black rail, and others. Vegetation management in these

areas would have the same potential effects as described for lake and pond habitats and would be avoided and/or minimized by the BMPs in Table 5-3 relating to agency communication, environmental training, pretreatment screening, and maintenance and in water work. With these BMPs implemented, the effects of this activity would be less than significant.

5.2.5.3.11 Seasonal Wetlands (includes Vernal Pools)

Seasonal wetlands, including vernal pools, may also support substantial stands of emergent vegetation, although these areas are typically not inundated for long enough periods to support dense stands of vegetation preferred by mosquitoes. As a result, these areas are unlikely to be subject to vegetation management actions. Terrestrial species that might occur here include tricolored blackbird, alkali milk-vetch, Sonoma sunshine, Mead's owls-clover, and others as indicated in Tables 4-3 and 4-4. If vegetation management activities were required, potential effects would be avoided and minimized by the BMPs in Table 5-3 relating to agency communication, environmental training, and pretreatment screening.

The District has long-standing cooperative and collaborative relationships with CDFW, professional biologists and property owners with regard to access, mosquito surveillance and control in association with vernal pools. District staff have received information and training from CDFW and professional biologists with respect to minimizing the potential for impacts to vernal pool habitat and specifically California tiger salamander, Sebastopol meadowfoam, Burke's goldfields, and Sonoma sunshine. When using ATVs to perform vegetation management in the proximity of vernal pools, District staff stay outside of the margin of the vernal pools (delineated by vegetation change from wetland to upland), and do not operate ATVs within wetland vegetation or the actual vernal pool. When possible, District staff performs vegetation management with hand equipment, with access on foot or by operating ATVs in upland areas a considerable distance from the pools When it is necessary to use an ATV for vegetation management in proximity to vernal pools, the District utilizes low ground pressure vehicles. District staff operates ATVs at slow speeds on sites containing vernal pools, and remains observant while operating equipment and walking in and amongst vernal pool habitat. The District avoids performing vegetation management on rainy days or during dawn and dusk to avoid peak movement periods for California tiger salamander.

The Vegetation Management Alternative would not result in the direct removal, filling, or hydrological interruption of federally protected wetlands as defined by CWA Section 404 (including, but not limited to, marsh, vernal pool, coastal, etc.). It may result in the removal of minor amounts of vegetation in these areas. All work in wetlands would be subject to additional permitting by the USACE, CDFW, BCDC, and RWQCB. Vegetation management-specific BMPs will be applied if necessary (see Table 5-3). With these BMPs and the practices described above, the effects of vegetation management activities on seasonal wetlands would be less-than-significant.

5.2.5.3.12 Lagoon

Lagoons would support mosquitoes in areas of reduced circulation, often associated with emergent vegetation, supporting a number of special-status species as identified in Tables 4-3 and 4-4, including many of the marsh and riparian species listed previously. Vegetation management in lagoons would be subject to the BMPs in Table 5-3 to avoid or minimize impacts to environmental resources. With these BMPs, the effects of the Vegetation Management Alternative on biological resources within lagoons would be less-than-significant.

5.2.5.3.13 Tidal Marsh and Channels

Vegetation management activities are conducted in coordination with landowners or land managers and the resource agencies and generally focus on the removal of nondesired plant species. Tidal marshes may support a number of special-status plants, including pappose tarplant, soft bird's beak, and others (Table 4-3), and animals, including salt-marsh harvest mouse, Suisun shrew, Ridgway's rail, northern harrier, tricolored blackbird, and other passerine species (Table 4-4). Vegetation removal in tidal marshes

is done using hand tools and in accordance with the tidal marsh-specific BMPs identified in Table 5-3, and others relating to agency coordination, environmental training, pretreatment screening, disturbance minimization BMPs, as well as vegetation management and species-specific BMPs. With these BMPs, the effects of the Vegetation Management Alternative on biological resources within or dependent upon tidal marshes would be less-than-significant.

5.2.5.3.14 Water and Wastewater Treatment Facilities

Vegetation management activities may occur in coordination with the owners or operators of wastewater treatment facilities or septic/onsite wastewater treatment systems. These facilities may provide nesting habitat for special-status avian species such as northern harrier hawk since such facilities may lie close to suitable habitats in streams or the San Francisco Bay Delta system. The extent to which these species may enter these facilities is unknown. Septic systems and their associated leach fields may provide habitat for special-status avian species, particularly those that nest in riparian or emergent vegetation. Because of the limited number of such facilities and the very limited use of such facilities by special-status species, vegetation management measures would have a less-than-significant impact on terrestrial special-status species and will be minimized with the implementation of the BMPs in Table 5-3 particularly those pertaining to agency communication, pretreatment screening, and environmental training.

5.2.5.3.15 Artificial Containers, Temporary Standing Waters, and Ornamental Ponds

Vegetation management does not occur in artificial containers. Artificial containers do not provide habitat for nor support populations of native or special-status terrestrial species. Thus, this alternative would have no impact on these species or their habitat.

Temporary standing waters refer to water ponding on an upland habitat because of rainfall or irrigation. Ornamental ponds are small ponds with artificial bottoms. These habitats do not provide habitat for special-status aquatic or terrestrial species. Therefore, no impact would occur to special-status species from the vegetation management alternative in these habitats.

5.2.5.3.16 Impact Determinations for Special-Status Species and Habitats

Impact TR-13. The Vegetation Management Alternative would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.

Impact TR-14. The Vegetation Management Alternative would have a **less-than-significant** impact on any riparian habitat or other sensitive natural community. No mitigation is required.

Impact TR-15. The Vegetation Management Alternative would have a **less-than-significant** impact on federally protected wetlands as defined by CWA Section 404. No mitigation is required.

5.2.5.4 Effects on Movement and Migration

The Vegetation Management Alternative could have a small effect on the migration of wildlife and movement and migration corridors. The removal of small areas of vegetation would not substantially affect movement corridors, but the presence of personnel and machinery may result in short-term avoidance of active work areas by terrestrial animals. In all cases this occurrence would be short term, generally not more than a few hours to a few days in any given location. Therefore, this minimal effect would have little impact on the movement of wildlife. It would not affect wildlife migration corridors or nursery areas, as no physical disturbance to these areas would occur.

Impact TR-16. The Vegetation Management Alternative would have a **less-than-significant** impact on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites. No mitigation is required.

5.2.5.5 Conflict with Local Ordinances

The county and city general plans and their goals and policies pertaining to natural resources are protective of terrestrial resources and focused on conservation of existing resources including mature trees and important woodland communities. Vegetation management activities would not result in the conversion of natural habitats to other land uses or in the long-term or permanent dislocation of plant and animal species from natural areas except indirectly for mosquitoes and vectors of disease and discomfort. Vegetation removal would not affect trees more than 4 inches diameter at breast height and, therefore, would not conflict with local tree ordinances.

Impact TR-17. The Vegetation Management Alternative would have **no impact** on local policies or ordinances protecting terrestrial resources.

5.2.5.6 Conflict with Conservation Plans

Two conservation plans, Turkey Road and the SRPCS, were identified whose action areas are within the District's primary Service Area. The Turkey Road HCP provides for protection and mitigation of impacts to California red-legged frog associated with residential and vineyard development. The SRPCS provides for the protection and mitigation of impacts to California tiger salamander and four listed plant species from development on the Santa Rosa Plain.

The District conducts limited vegetation control operations within the area covered by the regional SRPCS. The District regularly communicates with and works collaboratively with the SRPCS IRT and representatives from agencies such as SWQCB, USEPA, USACE, CDFW, and USFWS. The District receives training from agency staff (e.g., CDFW, USACE) and independent biologists to minimize impacts and conducts annual field training for field staff regarding precautionary and avoidance measures related to vernal pool habitat. The District uses specialized equipment in conjunction with vernal pool habitats.

Six conservation plans affect portions of adjacent counties. District activities are typically not among those covered by these HCPs. When called into these adjacent counties to perform work, the District would operate under the auspices of that county or their mosquito and vector control district and in compliance with their practices and permits, including compliance with all active HCP/NCCPs. Therefore, the District activities would not be in conflict with the provisions of any adopted HCP, NCCP, or other approved local, regional, or state-approved conservation plan.

Impact TR-18. The Vegetation Management Alternative has a **less-than-significant** impact on approved HCPs or NCCPs. No mitigation is required.

5.2.6 Biological Control Alternative

Biological control of mosquitoes involves the intentional use of vector pathogens, parasites, and predators to reduce the mosquito population. Its emphasis, as it currently exists in the District's IVMP, is on control of mosquitoes in their immature stages in artificial waterbodies that are not connected to natural waterbodies using a mosquito predator. Currently, no commercial biological control agents or products are available for wasp and yellow jacket control, and the District does not employ predators (e.g., cats) for rodent control.

As part of their Biological Control Alternative, the District employs bacterial larvicides that are highly specific to mosquitoes. These biological controls include Bs, a bacterial pathogen of mosquitoes, or Bti, which are nonliving by-products of bacteria that paralyze the gut of larval mosquitoes when ingested. (Because the potential environmental impacts of Bs or Bti application are generally similar to those of

chemical pesticide applications, these materials and spinosad are evaluated under Section 5.2.7.1.1, Chemical Control Alternative. The environmental fate and toxicity of these control agents are discussed further in Appendix B.

5.2.6.1 Impacts to Special-Status Species

Mosquitofish (Gambusia affinis) are presently the only commercially available mosquito predators. The District's purchase and use of these fish in mosquito habitats is the most commonly used biological control agent for mosquitoes in the world. Used correctly, this fish can provide effective, and persistent suppression in various mosquito sources. However, due to concerns that mosquitofish may potentially impact red-legged frog and tiger salamander populations in natural waterbodies, the District limits the use of mosquitofish to artificial waterbodies (such as ornamental fish ponds, water troughs, water gardens, fountains, and unmaintained swimming pools) and other types of isolated man-made ponds that do not provide habitat that could support native species. These artificial habitats are not included in HCPs/NCCPs. The Biological Control Alternative's use of mosquitofish would have no impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the CDFW or USFWS, as the use of this alternative would be confined to artificial environments that are not connected to natural environments where special-status species occur.

> **Impact TR-19.** The Biological Control Alternative would have **no impact** either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species.

5.2.6.2 Impacts to Habitats

The use of mosquitofish for biological control of mosquitoes would not affect any natural habitats identified in local or regional plans, policies, or regulations, or by the CDFW or USFWS or result in the presence of District personnel or equipment in natural habitats. Mosquitofish would not be used in federally protected wetlands as defined by CWA Section 404 (including, but not limited to, marsh, vernal pool, coastal, etc.). Therefore, it would not affect the quantity or distribution of habitats, such as riparian areas, marshes, lakes or ponds, seasonal wetlands, or other natural habitat types. This alternative would not affect the composition of their vegetative communities. This alternative would not result in any ground-disturbing activity and, therefore, would not result in any removal, filling, or hydrologic interruption of federally protected wetlands.

> **Impact TR-20.** The Biological Control Alternative would have **no impact** on any riparian habitat or other sensitive natural community.

> **Impact TR-21.** The Biological Control Alternative would have **no impact** on federally protected wetlands as defined by CWA Section 404.

5.2.6.3 Effects on Movement and Migration

Because mosquitofish would only be used in artificial bodies of water not connected to natural waterways or wetlands, this alternative would not occur in natural environments and would have no effect on the movement of wildlife and would not affect wildlife migration or movement corridors or impede the use of native wildlife nursery sites.

> **Impact TR-22.** The Biological Control Alternative would have **no impact** on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites.

5.2.6.4 Conflict with Local Ordinances

The county and city general plans and their goals pertaining to natural resources are protective of terrestrial resources and focused on conservation of existing resources including mature trees and important woodland communities. Biological control activities with mosquitofish would not result in the conversion of natural habitats to other land uses or in the long-term or permanent dislocation of plant and animal species from natural areas except for mosquitoes and vectors of disease and discomfort. This alternative would not affect trees more than 4 inches diameter breast height and, therefore, would not conflict with local tree ordinances.

> **Impact TR-23.** The Biological Control Alternative would have **no impact** on local policies or ordinances protecting biological resources.

5.2.6.5 Conflict with Conservation Plans

Two conservation plans, Turkey Road and the SRPCS, were identified whose action areas are within the District's primary Service Area. The Turkey Road HCP provides for protection and mitigation of impacts to California red-legged frog associated with residential and vineyard development. The SRPCS provides for the protection and mitigation of impacts to California tiger salamander and four listed plant species from development on the Santa Rosa Plain in Sonoma County. The District regularly communicates with and works collaboratively with the SRPCS IRT and representatives from agencies such as SWQCB, USEPA, USACE, CDFW, and USFWS.

Biological control with mosquitofish would be implemented only in artificial habitats where these habitats do not connect to other waters that could support special-status species within the boundaries of these two conservations plans.

Six conservation plans affect portions of adjacent counties. The District would not implement biological control with mosquitofish within the boundaries of these plan areas. District activities are typically not among those covered by these HCPs. When called into these adjacent counties to perform work, the District would operate under the auspices of that county or their mosquito and vector control district and in compliance with their practices and permits, including compliance with all active HCP/NCCPs. Therefore, the District activities would not be in conflict with the provisions of any adopted HCP, NCCP, or other approved local, regional, or state-approved conservation plan.

> **Impact TR-24**. The Biological Control Alternative would have **no impact** on approved HCPs, NCCPs, or local conservation plans.

5.2.7 Chemical Control Alternative

Chemical control consists of the application of pesticides to directly reduce populations of vectors that pose a risk to public health. The majority of chemical control tools are used for mosquito abatement. These chemicals (active ingredients) can be used as mosquito larvicides or adulticides. See Table 2-2 for mosquito larvicides and Table 2-3 for mosquito adulticides that are proposed for inclusion in the IVMP. Chemical control is also used to control nuisance populations of yellow jackets. The Chemical Control Alternative would be primarily a continuation of existing activities using applicable techniques, equipment, vehicles, watercraft, and aircraft. The District does not currently perform control work with respect to tick populations but may potentially do a limited amount of control work in the future. The District does not use chemical control for rodents.

As part of its IVMP, the District prioritizes the least toxic materials available for control of the larval stages, focusing on bacterial larvicides, growth regulators, and surface films rather than pyrethroids. Control of adult mosquitoes may become necessary under some circumstances, such as in the event of a disease outbreak (documented presence of infectious virus in active host-seeking adult mosquitoes), or lack of access to larval sources and habitats leading to the emergence of large numbers of biting adult mosquitoes. The active ingredients currently used for control of adult mosquitoes have been deliberately

selected for lack of persistence and minimal effects on nontarget organisms when applied at label rates allowed for ULV mosquito control.

The District also uses insecticides to control populations of ground-nesting yellow jackets. This activity is generally triggered by public requests rather than as a result of regular surveillance activities. The District does not treat yellow jacket nests that are located inside or on a structure; instead, the resident is encouraged to contact a private pest control company. Likewise, residents complaining of honeybee swarms or hives are referred to the County Agricultural Commissioner's Office for a referral list of beekeepers. If District technicians deem it appropriate to treat stinging insects, they will apply the insecticide directly within the nest to avoid drift or harm to other organisms. Alternatively, they will place tamper-resistant traps or bait stations, selective for the target insect, in the immediate environment. Chemicals used in the traps are contained and do not interact with the environment.

All chemicals the District uses (Tables 2-2 through 2-4 in Chapter 2) are applied in strict conformance with label requirements, which have been approved by the USEPA and CDPR for use in California when applied with strict adherence to product label requirements, and with additional BMPs listed in Table 5-3 (in particular, BMPs H1 through H14). Pesticide labels are legal requirements and include instructions telling users how to apply the product and precautions the applicator should take to protect human health and the environment. In addition, chemicals are applied in conformance with the PAP as required by the NPDES Vector Control Permit. With the application of these requirements and District BMPs, these chemicals should not result in adverse effects to nontarget terrestrial organisms.

Detailed discussions of the environmental fate and toxicity of these active ingredients and potential for bioaccumulation are provided in Appendix B and in Section 6.2.7. A subset of the pesticides (Table 5-6) available for District use was identified for further examination based upon use patterns and toxicity (Appendix B, Table 1-1). The following discussion groups these chemicals based on their target organism or life stage and discusses these pesticides in reference to impacts to terrestrial nontarget organisms.

Table 5-6 Chemical Control Active Ingredients and Adjuvants Identified in Appendix B

Active Ingredient	Vector	Potential Issue
Methoprene	Mosquitoes	Prevalent use; toxicity to aquatic insects; potentially bioaccumulative
Etofenprox	Mosquitoes	Toxicity to aquatic organisms; no synergist required; potentially bioaccumulative
Bti	Mosquitoes	Prevalent use; public concerns
Pyrethrins	Mosquitoes/yellow jacket wasps	Prevalent use; requires synergist (PBO)
Resmethrin	Mosquitoes	Requires synergist (e.g., PBO); potential endocrine disruptor
Plant oils/ mineral oils	Mosquitoes (surfactant)	Percentage of petroleum distillate (if any)
Permethrin	Mosquitoes/ yellow jacket wasps	Toxicity to aquatic organisms; potential endocrine disruptor

See Appendix B, Table 1-1

The District would use a variety of techniques and equipment to apply mosquito larvicides and adulticides, including hand-held sprayers, backpack sprayers and blowers, truck- or ATV-mounted spray rigs, watercraft, and helicopters or other aircraft. Equipment used in ground applications of liquid formulations include hand-held sprayers (handcans or spray bottles), and backpack sprayers and blowers. Hand-held sprayers (handcans) are standard 1- or 2- or 3-gallon garden style pump-up sprayers used to treat very small isolated areas. Backpack sprayers are either hand pump-up for liquid applications and have a 2.5/3- to 5-gallon tank

or are gas powered. When large areas are simultaneously producing mosquito larvae at densities or in levels of abundance, exceeding District treatment guidelines, then the District may use helicopters or other aircraft to apply larvicides (and adulticides). Aerial application of larvicides is a relatively infrequent activity for the District with each application covering from approximately 20 to 600 acres. Aerial application by helicopter of liquid larvicides typically occurs during daylight hours and at an altitude above the treatment site of approximately 50 feet or less. Granular applications by helicopter would occur during daylight hours at a 50-foot altitude or less.

Aerial applications at larvicides and adulticides using helicopters and potentially fixed-wing aircraft are used to obtain effective control in areas bordered by extensive mosquito production sites or with small, narrow, or inaccessible network of roads. The flight parameters differ by program and technique. Some operations fly during hours of daylight so their applications begin either at morning's first light or before sunset and work into twilight. For adulticides, the aircraft can be flown at a less than 200-foot altitude, which may make it easier to hit the target area. Other operations may be conducted in the dark of the night, typically after twilight or early in the morning before dawn. The aircraft typically are flown between 200- and 300-foot altitudes. Swath widths vary from operation to operation but are normally set somewhere between 400 and 1,200 feet. Aerial applications may be conducted over, but are not limited to, the following land uses within the Program Area: salt marsh, diked marsh, seasonal wetlands; evaporation ponds and wastewater ponds; and agricultural, residential, commercial, industrial, and recreational areas.

5.2.7.1 Impacts to Special-Status Species

5.2.7.1.1 Mosquito Larvicides

As part of their Chemical Control Alternative, the District employs bacterial agents that are highly specific to mosquitoes. These controls include the active ingredients Bs (a live bacteria), and Bti and spinosad (bacterial by-products that are toxic to mosquitoes). Larvicides are used to manage immature life stages of mosquitoes (larvae) in aquatic and wetland habitats, as described previously. They are not applied in upland habitats, with the exception of temporary rainwater pools, seeps, and treeholes, although a small amount of spray drift may occur. These habitats may support special-status terrestrial species as indicated in Tables 4-3 and 4-4. The larvicides are applied using ground application equipment, fixed wing aircraft (in the future), and rotary aircraft, as described in Chapter 2 and listed in Table 2-5. District guidelines for selecting application methods are predicated upon access, efficiency and effectiveness of application, size of the area to be treated, and the density, abundance, and type of vegetation present at the application site (i.e., the likelihood of success in applying the material to the target area). The potential impact of equipment noise on wildlife would be minimal, as the animals would return to their selected habitats within a few hours at most for application techniques the District currently uses.

The toxicity of Bs, Bti, spinosad, methoprene, and surfactants are discussed in detail in Appendix B and listed in Table 5-7. The District employs BMPs to reduce the relative potential impacts of these chemical options to nontarget organisms as well as to applicators. Because Bs, Bti, and spinosad are applied to aquatic rather than terrestrial environments to control larval mosquitoes, the potential for exposure of terrestrial organisms is low. Drift of these chemicals to nontarget areas is minimized through application of BMPs, including observance of wind and weather conditions.

Table 5-7 Chemical Control Options for Larval Mosquito Abatement as Discussed in Appendix B

Chemical Classification	Active Ingredient	Appendix B
Bacterial larvicide	Bs	Section 4.3.1
Bacterial larvicide	Bti	Section 4.3.2
Bacterial larvicide	Spinosad	Section 4.3.3
Hydrocarbon ester	Methoprene and s-Methoprene	Section 4.3.4
Surfactant	Alcohol Ethoxylated Surfactant (monomolecular film)	Section 4.3.5
Surfactant	Aliphatic solvent (mineral oil, BVA-2, CoCoBear)	Section 4.3.6

Bacterial Larvicides (BS, Bti, Spinosad)

Bacterial larvicides such as Bti and Bs are highly selective microbial pesticides (for mosquitoes) that when ingested, produce gut toxins that cause destruction of the insect gut wall leading to paralysis and death. These microbial agents are delivered as endospores in granular, powder, or liquid concentrate formulations. Bs and Bti are applied directly to larval mosquito habitats (water) rather than to terrestrial environments. These products are applied in adherence to product labels, and all appropriate BMPs are applied when they are used. Bs and Bti are practically nontoxic to terrestrial organisms, including birds, bees, and mammals.

Spinosad is a natural insecticide derived from the fermentation of a common soil microorganism, Saacharopolyspora spinosa. Spinosad causes neurologic effects in insects consistent with the general activation of nicotinic acetylcholine receptors, but by a mechanism that is novel among known insecticides (Mayes et al. 2003). Exposure manifests as constant involuntary nervous system impacts ultimately leading to paralysis and death of the insect. Spinosad is highly effective against lepidopteron larvae (e.g., butterflies and moths), as well as some Diptera (mosquitoes and flies), Coleoptera (beetles), Thysanoptera (e.g., thrips), and Hymenoptera (e.g., bees, wasps) (Mayes et al. 2003). The effects of spinosad on beneficial pollinators such as honeybees are of concern. The District incorporates BMPs that are designed to minimize exposure of bees to spinosad, such as restricting applications to nighttime hours when bees are inactive, covering hives where possible with wet burlap and maintaining buffer zones. Bees and other nontarget insects may contact spinosad residues following applications; however, residues generally are below acute toxicity thresholds to honeybees. Field studies evaluating typical spinosad applications have demonstrated low risk to adult honeybees and little to no effect on hive activity and brood development, provided that the residue is allowed to dry for up to 3 hours (Mayes et al. 2003).

Spinosad is of low acute toxicity to birds and mammals. Generally, spinosad is applied directly to larval mosquito habitat, thereby reducing potential exposures of sensitive terrestrial insects including moths, butterflies, and honeybees. Application of spinosad follows strict product label descriptions.

Hydrocarbon Esters (Methoprene)

(S)-Methoprene is a hormone analogue that interferes with insect larval development (growth regulator). This chemical does not exhibit the nonspecific target effects of neurological toxins such as pyrethrin.

Methoprene is used as a larvicide and, as such, is not applied to terrestrial environments. Some drift into terrestrial environments may occur when it applied, but it is almost irrelevant for hand and aerial (e.g., helicopter) applications since treatments are restricted at moderate to high wind speeds. Methoprene is considered one of the most environmentally compatible of all larvicide options, and the District uses methoprene prevalently throughout the year. Methoprene is highly effective against mosquitoes at low concentrations (very low volume applications are used when possible) and degrades quickly in the

environment, thereby reducing the potential exposure and risk to nontarget organisms. The District infrequently apply(ies) methoprene to vernal pools. Methoprene may be applied when mosquito populations are abundant in the pools and when mosquitoes have reached the later stages of development. Methoprene may be applied when feasible when requested by a regulatory agency. The District typically uses Bti and Bs in these environments. Extended release methoprene products are typically not used in vernal pool habitats.

Methoprene has high toxicity to nontarget insects such as moths, butterflies, and beetles, but only at much higher concentrations than those used for mosquito control; however, moths, butterflies, and most species of beetles do not occupy aquatic habitats and so would have very limited exposure.

The District uses methoprene prevalently during each season of the year. Liquid and granular forms are used in residential and ornamental pond application scenarios. Treatments to wetlands including marshes, at times require the granular form (e.g., Altosid pellets) to penetrate dense aquatic vegetation including cattails and tules. See Section 9.2.7.1 for discussion of use of methoprene in malfunctioning onsite wastewater treatment systems due to improper lid seals, cracks, or missing vent screens and/or due to drain fields where water ponds on the surface.

Surfactants

Petroleum- (aliphatic solvents) and plant-based (ethoxylated isostearyl alcohols) oils are used as surface-active agents effective against larvae and pupae. These oils are effective against these immature life stages when inhaled at the water surface or by physically forming a surface film that drowns the mosquito. These treatments may also be effective against adult mosquitoes during adult emergence. They are specific to aquatic environments and are not applied to terrestrial environments, although some drift may occur.

> **Impact TR-25**: The Chemical Control Alternative's mosquito larvicides would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.

5.2.7.1.2 Mosquito Adulticides

In addition to chemical control of mosquito larvae, the District may use pesticides for control of adult mosquitoes when other tools are not available or applicable and if specific guidelines are met, including species composition, population abundance and/or density (as measured by landing count or other quantitative method), proximity to human populations, and/or human disease risk. Adulticides are can be used over vegetated areas preferred by adult mosquitoes (see Section 4.2.7.1.2). Treatment of adults is employed when physical controls and larviciding are not sufficiently effective, not possible, or applicable. As with larvicides, adulticides are applied in strict conformance with label requirements (Appendix B). Adulticides the District uses are listed in Table 5-8. The use of adulticides has not been required in direct association with mosquito production in vernal pools and this is not anticipated to be an issue in the foreseeable future. The District will use all available means to avoid use of adulticides over vernal pool habitats. If the use of adulticides over vernal pools were to become necessary within close proximity (relative to swath widths of ULV application equipment) to vernal pools, the District would notify the USFWS and CDFW of the need, and applications would be performed in strict accordance with the product label, using the appropriate BMPs as listed in Table 5-3, and in consultation with property owners. A detailed discussion of the environmental fate and toxicity of these pesticides is provided in Appendix B. The potential impact on wildlife from noise associated with equipment use would be minimal, as the animals would return to their selected habitats within a few hours at most for application techniques the District currently uses.

Table 5-8 Chemical Control Options for Adult Insect Abatement as Discussed in Appendix B

Chemical Classification	Active Ingredient	Vector	Appendix B
Pyrethrin	Pyrethrins	Mosquito; yellow jacket	Section 4.1.1
Synthetic Pyrethroid	Allethrin and d-*trans* allethrin	Yellow jacket ; tick	Section 4.1.2
Synthetic Pyrethroid	Phenothrin (sumithrin or d-phenothrin)	Mosquito; yellow jacket	Section 4.1.3
Synthetic Pyrethroid	Prallethrin	Mosquito	Section 4.1.4
Synthetic Pyrethroid	Deltamethrin	Tick; yellow jacket, tick	Section 4.1.5
Synthetic Pyrethroid	Esfenvalerate	Yellow jacket, tick	Section 4.1.6
Synthetic Pyrethroid	Resmethrin	Mosquito	Section 4.1.8
Synthetic Pyrethroid	Tetramethrin	Yellow jacket	Section 4.1.9
Synthetic Pyrethroid	Permethrin	Mosquito; yellow jacket	Section 4.1.10
Pyrethroid-like	Etofenprox	Mosquito; yellow jacket	Section 4.1.11
Synergist	PBO	Mosquito; yellow jacket	Section 4.1.12

Pyrethrins

The District uses pyrethrin for mosquito and/or yellow jacket wasp control. For yellow jacket control, pyrethrin is applied around parks, landscaping, and directly into ground nests. For adult mosquito control, pyrethrins may be applied over a wide range of land uses and habitat types. However, the District uses pyrethrins only when absolutely necessary due to mosquito abundance and density in an area; and, even then, minimal amounts are applied (via ULV application), thus reducing the potential for impacts to nontarget ecological receptors (BMPs H3, H4, H11). As an additional measure, pyrethrin applications are canceled during less than ideal wind and potential drift conditions (BMP H6). For wasp (yellow jacket and paper wasps) control, the District applies pyrethrins in minute volumes directly to ground nests and tree nests if necessary, which essentially negates any impact to nontarget species. The District ensures that all applications are made in accordance with label specifications and USEPA and CDPR recommendations for use with mosquitoes. Other practices that can alleviate risk to aquatic receptors include minimizing the amount, frequency, and area with which these pesticides are applied over waterbodies, especially those with the potential to contain special-status species. The District also minimizes the amount, frequency, and area with which these pesticides are applied over waters draining directly to the waters above. In addition, the risks to nontarget insects such as honeybees are reduced by restricting pyrethrin applications to nighttime, predawn, and dusk hours when bees and other pollinators are inactive (BMP H12).

Pyrethrins readily degrade in water and soil, but may persist under anoxic conditions. They tend to strongly adsorb to soil surfaces and, hence, have low potential to leach into groundwater. Pyrethrins may be highly toxic to fish (freshwater, estuarine, marine) and invertebrates, although exposures would likely be low during and following ULV applications, which are designed to prevent environmental persistence and potential impacts to nontarget ecological receptors.

Pyrethrins have low to moderate acute toxicity to mammals via the oral, dermal, and inhalation routes and are practically nontoxic to birds. When applying to areas larger than 0.25 acres, the risks to nontarget insects such as honeybees are reduced by only applying pyrethrins at night in the dark when bees and other pollinators are inactive (BMP H12). The District also coordinates their activities with local beekeepers (when known or discovered via notifications) to further minimize risk of exposure to bees. Beekeepers will cover or move their hives during applications of these chemicals, uncovering or returning them to the area within a few hours after spraying. This coordination has worked satisfactorily for both the beekeepers and

the District. Little risk to nontarget terrestrial organisms is expected when this and other BMPs to avoid unwanted drift are applied.

Pyrethroids and Pyrethroid-Like Compounds

Pyrethroid insecticides are synthetic compounds that are chemically similar to the pyrethrins but have been modified to increase stability and activity against insects. Some synthetic insecticides are similar to pyrethroids, such as etofenprox, but have a slightly different chemical composition. First generation or "Type I" photosensitive pyrethroids include d-allethrin, phenothrin (sumithrin), prallethrin, resmethrin, and tetramethrin. Typically, these pyrethroids are used indoors and around residential areas. The newer second-generation pyrethroids are mostly "Type II" pyrethroids. Type II pyrethroids are more toxic (than Type I pyrethroids) because they are less photosensitive and persist longer in the environment. The active ingredients that fall into this group include deltamethrin, esfenvalerate, and permethrin.

Pyrethroids affect insect neuroactivity by binding to a protein at the nerve fiber that regulates the voltage-gated sodium channel, This binding can delay the closing of sodium channels and/or cause a persistent activation of the sodium channels, which often results in repetitive activity (Type I pyrethroid) or blockage of nerve conduction (Type II pyrethroid). Most pyrethroids and pyrethroid-like compounds are of low toxicity to birds and mammals, but of high toxicity to honeybees. The risks to nontarget insects such as honeybees are reduced by restricting application of these compounds to night and predawn times, when bees and other pollinators are inactive. The District also coordinates their activities with local beekeepers (when known or discovered via notifications) to further minimize risk of exposure to bees. Beekeepers will cover or move their hives during applications of these chemicals, uncovering or returning them to the area within a few hours after spraying. The active ingredients that have been selected for further evaluation in Appendix B (resmethrin, permethrin, and etofenprox) are discussed individually below.

Resmethrin

The District rarely uses resmethrin, unless no other adulticides are applicable or effective. The District may apply(ies) resmethrin in situations such as, in association with adult tree hole mosquito populations, residential areas near reclaimed marshes, and industrial areas for mosquito control. ULV applications of resmethrin would be used, and this chemical is also reserved for use when circumstances are critical (e.g., an outbreak of infectious disease such as West Nile virus). Additionally, resmethrin use is declining in favor of nonresmethrin alternatives. Studies have shown rapid dissipation/low persistence following aerial ULV applications. Resmethrin is moderately toxic to birds and highly toxic to honeybees; however, little risk to nontarget terrestrial organisms is expected when BMPs such as spray nozzle adjustments (BMP H8) and insect pollinator protection (BMP 12) are applied.

Permethrin

The District may use permethrin for mosquito and/or yellow jacket wasp control during spring, summer, and fall. Permethrin products are used in reclaimed marshes, used around residences, and applied directly to ground nests. Permethrin has low toxicity to mammals and is practically nontoxic to birds. It is highly toxic to honeybees; however, this pesticide is generally used with careful and strict BMP techniques such as using very small, localized applications. When used appropriately, little risk to nontarget terrestrial organisms is expected.

Etofenprox

Etofenprox is a pyrethroid-like compound that does not tend to persist in the environment or appear to pose a risk to mammals as it is available to the general public for application to backyards and patios and is sometimes applied directly to domestic pets (for flea and tick control).

Etofenprox is generally applied during the nighttime hours when sensitive receptors such as honeybees are not active. Based on toxicity, environmental fate, and usage patterns, etofenprox, using BMPs, is not likely to result in adverse impacts to nontarget terrestrial organisms.

> **Impact TR-26**: The Chemical Control Alternative's mosquito adulticides would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.

Synergist (Piperonyl Butoxide)

PBO was first registered in the 1950s and acts as a synergist. Synergists are chemicals that primarily enhance the pesticidal properties of other active ingredients, such as pyrethrins and synthetic pyrethroids. PBO is a registered active ingredient in products used to control many different types of flying and crawling insects and arthropods, although no products contain only PBO. It is registered for use in agricultural, residential, commercial, industrial, and sites of public health importance. PBO interferes with the insect's ability to detoxify pyrethrins and pyrethroids, by binding to microsomal enzymes in target organisms, thereby inhibiting the breakdown of other pesticides, including pyrethrins and pyrethroids (USEPA 2006a).

PBO degrades relatively rapidly in soil and water and, therefore, does not tend to persist in the environment. PBO may be highly toxic to some species of fish and aquatic invertebrates and is being evaluated as a possible endocrine disruptor. However, it is of low toxicity to terrestrial receptors such as mammals and honeybees. ULV applications of adulticides containing PBO are used whenever necessary and applicable and in conjunction with BMPs for the co-applied pesticides.

> **Impact TR-27**: The Chemical Control Alternative's use of the synergist PBO would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.

5.2.7.1.3 Yellow Jacket and Tick Abatement

Besides using insecticides for mosquito populations, the District selectively applies them (typically pyrethrin and some pyrethroids) to control ground-nesting yellow jacket and tick populations that pose an imminent threat to people or to pets. This activity is generally triggered by public requests for District assistance or action rather than as a result of regular surveillance of their populations. For control of yellow jackets and ticks, these pesticides are applied in highly localized, upland areas and residential areas.

The District excludes from its yellow jacket control program populations of this vector that are located in or on a structure. Yellow jacket nests that are off the ground would be treated under special circumstances to protect public health and safety of the District's residents. Whenever a District technician learns that a hive is situated inside or on a structure or is above ground, the resident(s) are encouraged to contact a private pest control company that is licensed to perform this work. Likewise, residents complaining of honeybee swarms or hives are referred to the County Agricultural Commissioner's Office for a referral list of beekeepers that can safely remove the bees. If District technicians deem it appropriate to treat stinging insects, they will apply the insecticide directly within the nest in accordance with the District's policies to avoid drift of the insecticide or harm to other organisms. Alternatively, they will place tamper-resistant traps or bait stations, selective for the target insect, in the immediate environment of the vector.

Pyrethrin and pyrethroid-based chemicals are typically used against ground-nesting yellow jackets. Examples of pesticides the District might employ to control yellow jackets and ticks in residential or upland environments are allethrin, deltamethrin, esfenvalerate, phenothrin, and tetramethrin. The potential environmental impacts of these materials are minimal due to the fact that they are applied directly to the underground nest and to vegetation supporting ticks in a localized area. This application method prevents drift and further reduces the potential for inadvertent exposure of nontarget and sensitive species to these

materials. These chemicals would be applied in strict accordance with label directions and District BMPs, including those relating to worker environmental awareness training, disturbance minimization measures, and "Applications of Pesticides, Surfactants, and/or Herbicides," will be applied, as will appropriate habitat and species-specific BMPs for access to sites to conduct treatment from the ground. The pesticides the District uses to control yellow jacket populations are shown in Table 2-5 and Table 5-9, and those selected for further review in Appendix B have been discussed previously.

The District typically does not engage in tick control activities, but could in the event of a tick-borne disease outbreak. In such an event, the District would employ pyrethroid-based chemicals; allethrin, deltamethrin, and esfenvalerate are under consideration. These are discussed further below.

Pyrethrin

The District uses pyrethrin for mosquito and/or yellow jacket wasp control. For yellow jacket control, pyrethrin is applied directly into ground nests. The potential impacts to terrestrial habitats through reduction of the amount or quality of habitat available, to native terrestrial plant or animal populations through direct mortality, or to special-status species are discussed above under mosquito adulticides (Section 5.2.7.1.2).

Pyrethroids and Pyrethroid-like Compounds

Pyrethroid insecticides are synthetic compounds that are chemically similar to the pyrethrins but have been modified to increase stability and activity against insects. First generation or "Type I" photosensitive pyrethroids include d-allethrin, phenothrin (sumithrin), prallethrin, resmethrin, and tetramethrin. Typically, these pyrethroids are used indoors and around residential areas. The newer second-generation pyrethroids are mostly "Type II" pyrethroids. The active ingredients that fall into this group include deltamethrin, esfenvalerate, and permethrin. Permethrin use is restricted to situations when it is absolutely necessary and in ULV applications that are designed to degrade rapidly and, thus, reduce the potential for impacts to nontarget ecological receptors. Type II pyrethroids are more toxic (than Type I pyrethroids) because they are less photosensitive and persist longer in the environment. Most pyrethroids and pyrethroid-like compounds are of low toxicity to birds and mammals, but of high toxicity to honeybees. The potential impacts to terrestrial habitats through reduction of the amount or quality of habitat available, to native terrestrial plant or animal populations through direct mortality, or to special-status species are discussed above under mosquito adulticides (Section 5.2.7.1.2).

The potential environmental impacts of these materials is minimal due to two factors: (1) their active ingredients consist largely of pyrethrins (a photosensitive natural insecticide manufactured from a Chrysanthemum species), or allethrin, and phenothrin (first generation synthetic pyrethroids with similar photosensitive, nonpersistent characteristics as pyrethrin); and (2) the mode of their application for yellow jacket population control (i.e., directly into the underground nest), which prevents drift and further reduces the potential for inadvertent exposure to these materials. When used for yellow jackets, the use would be confined to a single nest, not over a large area, as discussed for mosquito adulticiding. Because of the small quantity of pesticide applied and because these chemicals are not applied directly to aquatic environments, this control method would have little impact on aquatic or terrestrial organisms.

> **Impact TR-28**: The Chemical Control Alternative's use of pyrethrin, pyrethroids, and pyrethroid-like pesticides for yellow jacket wasp and tick control would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.

5.2.7.2 Impacts to Habitats

The Chemical Control Alternative would not affect the quantity or distribution of habitats, such as riparian areas, marshes, lakes or ponds, seasonal wetlands, or other habitat types identified in local or regional plans, policies, or regulations, or by the CDFW or USFWS. This alternative would not affect the composition of their vegetative communities, as the pesticides used would not be expected to affect

plants or their physical or hydrologic attributes. This alternative would not result in ground-disturbing activity and, therefore, would not result in any removal, filling, or hydrologic interruption of federally protected wetlands (including, but not limited to, marsh, vernal pool, coastal, etc.).

> **Impact TR-29.** The Chemical Control Alternative would have **no impact** on any riparian habitat or other sensitive natural community.

> **Impact TR-30.** The Chemical Control Alternative would have **no impact** on federally protected wetlands as defined by CWA Section 404.

5.2.7.3 Effects on Movement and Migration

Any disruption of migration patterns would be due to the presence of personnel and machinery in the environment. In all cases this occurrence would be very short term, generally not more than a few hours in any given location and, therefore, this effect would be minimal, would have little effect on the movement of wildlife, and would not affect wildlife migration corridors or nursery areas, as no physical disturbance would occur.

> **Impact TR-31.** The Chemical Control Alternative would have a **less-than-significant** impact on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites. No mitigation is required.

5.2.7.4 Conflict with Local Ordinances

The county and city general plans and their goals and policies pertaining to natural resources are protective of terrestrial resources and focused on conservation of existing resources including mature trees and important woodland communities. Chemical control activities would not result in the conversion of natural habitats to other land uses or in the long-term or permanent dislocation of plant and animal species from natural areas except indirectly for mosquitoes and vectors of disease and discomfort. The Program would not affect trees more than 4 inches diameter breast height and, therefore, would not conflict with any tree ordinances.

> **Impact TR-32.** The Chemical Control Alternative would have **no impact** on local policies or ordinances protecting terrestrial resources.

5.2.7.5 Conflict with Conservation Plans

Two conservation plans, Turkey Road and the SRPCS, were identified whose action areas are within the District's primary Service Area. The Turkey Road HCP provides for protection and mitigation of impacts to California red-legged frog associated with residential and vineyard development. The SRPCS provides for the protection and mitigation of impacts to California tiger salamander and four listed plant species from development on the Santa Rosa Plain.

The District may conduct chemical control operations within the area covered by the regional SRPCS. However, the District regularly communicates with and works collaboratively with the SRPCS IRT and representatives from agencies such as SWQCB, USEPA, USACE, CDFW, and USFWS. District staff receive training from agency staff (e.g., CDFW, USACE) and independent biologists to minimize impacts and conducts annual field training for field staff regarding precautionary and avoidance measures related to vernal pool habitat. The District uses specialized equipment in conjunction with vernal pool habitats. While District activities may occur within the boundaries of conservation areas, these activities are coordinated with the plan managers and would not be inconsistent with the provisions of any adopted HCP, NCCP, or other approved local, regional, or state habitat conservation plan.

Six conservation plans affect portions of adjacent counties. District activities are typically not among those covered by these HCPs. When called into these adjacent counties to perform work, the District would

operate under the auspices of that county or their mosquito and vector control district and in compliance with their practices and permits, including compliance with all active HCP/NCCPs. Therefore, the District activities would not be in conflict with the provisions of any adopted HCP, NCCP, or other approved local, regional, or state-approved conservation plan.

> **Impact TR-33**. The Chemical Control Alternative would have a **less-than-significant** impact on approved HCPs, NCCPs, or local conservation plans. No mitigation is required.

5.2.8 Other Nonchemical Control/Trapping Alternative

The trapping of rodents is conducted as part of disease surveillance/testing programs and may be utilized for surveillance and egregious situations regarding commensal rodents (e.g., roof rats and Norway rats) in the future. Rodent trapping is not and will not be performed routinely as a mass trapping control measure. Trapping of yellow jackets is conducted when these organisms pose a threat to public health and welfare. For yellow jackets, District staff place the tamper-resistant or baited trap(s) primarily at the request of the property owner or manager, although they also advise the landowner that trapping is generally ineffective at population control and that it is better to seek out and treat the nest. The District does not remove rats or yellow jackets that are in or on structures. When these requests for service are made, residents are referred to the local animal control or to a directory of private pest control companies. While it is conceivable that nontarget wildlife could be inadvertently trapped, the District conducts limited trapping and employs mechanisms and baits specific to target vectors to reduce the potential impacts to nontarget ecological receptors.

This alternative would be undertaken under prescribed circumstances in and around developed/urban areas that do not provide good habitat for special-status species. Rodent trapping may also be performed in more rural settings to collect blood samples to test for disease. Trapping of yellow jackets would not be expected to have any effect on special-status species or their habitats, as these traps are highly localized, self-contained, and inaccessible to these species. Traps for rodents are designed for small mammals and baited to attract the target species. These traps are usually not deployed in areas where special-status mammals occur. When trapping is required, the District consults with the CDFW and USFWS and obtains all appropriate permits for trapping. All animals captured, have a blood sample taken for testing and are released. A report of animals captured and released is filed in accordance with permit requirements. These traps are highly unlikely to attract special-status birds, reptiles or amphibians, and even more unlikely to capture special-status species. The placement and operation of these traps would not change the amount or physical properties of any type of habitat or alter the hydrology in any way. They would not impair migration or alter migratory corridors or nursery sites.

5.2.8.1 Impacts to Special-Status Species

The Other Nonchemical Control/Trapping Alternative would have a less-than-significant impact on terrestrial wildlife including terrestrial species identified as a candidate, sensitive, or special-status species in local or regional plans, policies, or regulations, or by the CDFW or USFWS. Trapping is limited in scope and performed only when vectors pose a threat to public health and welfare. It is implemented in areas unlikely to support special-status species, and traps are baited to attract the target vector species to avoid trapping other animals. General BMPs contained in Table 5-3 serve to minimize or avoid impacts associated with vehicle used to place and collect the traps.

> **Impact TR-34.** The Other Nonchemical Control/Trapping Alternative would have a **less-than-significant** impact either directly or through habitat modifications, on any terrestrial species identified as a candidate, sensitive, or special-status species. No mitigation is required.

5.2.8.2 Impacts to Habitats

This alternative would not affect the quantity or distribution of habitats, such as riparian areas, marshes, lakes or ponds, seasonal wetlands, or other habitat types or sensitive natural communities identified in local or regional plans, policies, or regulations, or by the CDFW or USFWS. Trapping would not affect the composition of their vegetative communities, as the placement of traps and baits would not affect plants. This alternative would not result in ground-disturbing activity and, therefore, would not result in any removal, filling, or hydrologic interruption of federally protected wetlands (including, but not limited to, marsh, vernal pool, coastal, etc.).

> **Impact TR-35.** The Other Nonchemical Control/Trapping Alternative would have **no impact** on any riparian habitat or other sensitive natural community.

> **Impact TR-36.** The Other Nonchemical Control/Trapping Alternative would have **no impact** on federally protected wetlands as defined by CWA Section 404.

5.2.8.3 Effects on Movement and Migration

Any disruption of migration patterns would be due to the presence of personnel to set traps in the environment. In all cases this occurrence would be very short term, generally not more than a few hours in any given location and, therefore, this effect would be minimal, would have little effect on the movement of wildlife, and would not affect wildlife migration corridors or nursery areas, as no physical disturbance would occur.

> **Impact TR-37.** The Other Nonchemical Control/Trapping Alternative would have **no impact** on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites.

5.2.8.4 Conflict with Local Ordinances

The county and city general plans and their goals and policies pertaining to natural resources are protective of terrestrial resources and focused on conservation of existing resources including mature trees and important woodland communities. Trapping activities would not result in the conversion of natural habitats to other land uses or in the long-term or permanent dislocation of plant and animal species from natural areas except indirectly for vectors of disease and discomfort. The Program would not affect trees more than 4 inches diameter breast height and, therefore, would not conflict with any tree ordinances.

> **Impact TR-38.** The Other Nonchemical Control/Trapping Alternative would have **no impact** on local policies or ordinances protecting terrestrial resources.

5.2.8.5 Conflict with Conservation Plans

Two conservation plans, Turkey Road and the SRPCS, were identified whose action areas are within the District's primary Service Area. The Turkey Road HCP provides for protection and mitigation of impacts to California red-legged frog associated with residential and vineyard development. The SRPCS provides for the protection and mitigation of impacts to California tiger salamander and four listed plant species from development on the Santa Rosa Plain.

The District may conduct nonchemical control/trapping operations within the area covered by the regional SRPCS. However, the District regularly communicates with and works collaboratively with the SRPCS IRT and representatives from agencies such as SWQCB, USEPA, USACE, CDFW, and USFWS. District staff receive training from agency staff (e.g., CDFW, USACE) and independent biologists to minimize impacts and conducts annual field training for field staff regarding precautionary and avoidance measures related to vernal pool habitat. The District uses specialized equipment in conjunction with vernal pool habitats. While District trapping activities may occur within the boundaries of conservation areas, these

activities are coordinated with the plan managers and would not be inconsistent with the provisions of any adopted HCP, NCCP, or other approved local, regional, or state habitat conservation plan.

Six conservation plans affect portions of adjacent counties. District trapping activities are typically not among those covered by these HCPs. When called into these adjacent counties to perform work, the District would operate under the auspices of that county or their mosquito and vector control district and in compliance with their practices and permits, including compliance with all active HCP/NCCPs. Therefore, the District activities would not be in conflict with the provisions of any adopted HCP, NCCP, or other approved local, regional, or state-approved conservation plan.

> **Impact TR-39**. The Other Nonchemical Control/Trapping Alternative would have **no impact** on approved HCPs, NCCPs, or local conservation plans.

5.2.9 Cumulative Impacts

"Cumulative impacts" are defined as "two or more individual effects which, when considered together, are considerable or compound or increase other environmental impacts (CEQA Guidelines Section 15355). Cumulative impacts, as they relate to terrestrial resources, include past, present, and reasonably foreseeable actions that potentially impact terrestrial mammalian and avian wildlife, reptiles, aquatic organisms, nontarget invertebrates and pollinators, and botanical resources. Cumulative impacts can result from individually minor, but collectively significant, projects taking place over a period of time. The determination is whether a proposed project's incremental contribution to a cumulative impact results in a potentially "considerable" (i.e., significant) cumulative impact, and, if so, whether that project's incremental contribution can be mitigated to a less-than-significant level. The cumulative impacts analysis for terrestrial resources is contained in Section 1.3, and the determinations of cumulatively considerable impacts are summarized here.

The Surveillance, Physical Control, Vegetation Management, Chemical Control, and Other Nonchemical Control Alternatives' impacts to terrestrial resources were determined to be less than significant or in some cases "no impact." The Biological Control Alternative's use of mosquitofish had no impact to terrestrial resources. The key issues for consideration herein are potential effects on beneficial insect pollinators from chemical applications and the potential cumulative impacts associated with the Vegetation Management and Chemical Control Alternatives' less-than-significant impacts.

- Effects on Pollinators: Colony collapse disorder (CCD) and the resulting decline in bee populations is an existing significant cumulative impact in the region. In general, while insect abatement activities may affect native pollinators near or adjacent to treatment areas, the District's careful practice of BMPs greatly reduces the potential cumulative impacts to nontarget pollinators. The Program's **less-than-significant impacts on insect pollinators related to mosquito and yellow jacket abatement activities would not be cumulatively considerable or significant**.
- Vegetation Management Alternative: Vegetation control activities the District may perform would be cumulative with those which other entities perform within the Program Area. Vegetation control activities may affect native plants, as these species may lie within treatment areas, but the effects on individuals of native species are minimized, and the overall effect is likely beneficial, as native species will have less competition in treated areas and, thus, would be expected to be more successful. Based on this conclusion, the Program's incremental **less-than-significant effects relating to weed abatement activities, when considered with other weed abatement activities in the Program Area, would not be cumulatively considerable or significant**.
- Chemical Control Alternative: The uses of pesticides under the Chemical Control Alternative would be cumulative with uses of pesticides by agricultural, industrial, governmental, and residential users, an existing significant cumulative impact. The District's relative contribution to the loads of such concentrations is small compared with other users. Applications of pesticides for vector control are most often at concentrations less than the maximum allowed on the product label, and nontarget species are

not substantially affected and acute toxicities are avoided. The amounts applied by the District for vector control are often substantially less than the amounts used in the laboratory toxicity studies. Because of the large safety factors used to develop recommended product label application rates, the amount of chemical resulting in demonstrated toxicity in the laboratory is much higher than the low exposure levels associated with an actual application for vector control. The District preferentially uses nonchemical alternatives and when using chemical alternatives, uses chemicals most often that are not persistent in the environment when chemicals are applied. As such, the District's Chemical Control Alternative does not contribute substantially to pesticide and herbicide exposures in the terrestrial environment. The Chemical Control Alternative has a **less-than-significant cumulative impact on terrestrial resource exposures to herbicides and pesticides**.

5.2.10 Environmental Impacts Summary

The Surveillance, Physical Control, Vegetation Management (including herbicide use), Biological Control, and Other Nonchemical Control/Trapping alternatives are expected to have less-than-significant to no impact on terrestrial resources (Table 5-9). The Chemical Control Alternative (including the mosquito larvicide, mosquito, yellow jacket wasp, and tick adulticide application scenarios [under existing BMPs]) is expected to have only minimal impacts to nontarget terrestrial resources that would be less than significant.

Table 5-9 Summary of Biological Resources - Terrestrial Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Biological Resources - Terrestrial						
Impact TR-1. The Surveillance Alternative would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	LS	na	na	na	na	na
Impact TR-2. The Surveillance Alternative would have a **less-than-significant** impact on riparian habitat or other sensitive natural communities. No mitigation is required.	LS	na	na	na	na	na
Impact TR-3. The Surveillance Alternative would have a **less-than-significant** impact on federally protected wetlands as defined by Section 404 of the Clean Water Act. No mitigation is required.	LS	na	na	na	na	na
Impact TR-4. The Surveillance Alternative would have **no impact** on the movement of any native resident or migratory fish or wildlife species, nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites.	N	na	na	na	na	na
Impact TR-5. The Surveillance Alternative would have **no impact** on local policies or ordinances protecting biological resources.	N	na	na	na	na	na
Impact TR-6. The Surveillance Alternative would have a **less-than-significant** impact on adopted HCPs or NCCPs. No mitigation is required.	LS	na	na	na	na	na
Impact TR-7. The Physical Control Alternative, would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	LS	na	na	na	na
Impact TR-8. The Physical Control Alternative, would have a **less-than-significant** impact on any riparian habitat or other sensitive natural community. No mitigation is required.	na	LS	na	na	na	na
Impact TR-9. The Physical Control Alternative would have a **less-than-significant** impact on federally protected wetlands as defined by CWA Section 404. No mitigation is required.	na	LS	na	na	na	na

Table 5-9 Summary of Biological Resources - Terrestrial Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact TR-10. The Physical Control Alternative would have a **less-than-significant** impact **on** the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites. No mitigation is required.	na	LS	na	na	na	na
Impact TR-11. The Physical Control Alternative would have **no impact** on local policies or ordinances protecting terrestrial resources.	na	N	na	na	na	na
Impact TR-12. The Physical Control Alternative would have a **less-than-significant** impact on adopted HCPs or NCCPs. No mitigation is required.	na	LS	na	na	na	na
Impact TR-13. The Vegetation Management Alternative would have a **less-than-significant** impact either directly or through habitat modifications, **on** any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	na	LS	na	na	na
Impact TR-14. The Vegetation Management Alternative would have a **less-than-significant** impact on any riparian habitat or other sensitive natural community. No mitigation is required.	na	na	LS	na	na	na
Impact TR-15. The Vegetation Management Alternative would have a **less-than-significant** impact on federally protected wetlands as defined by CWA Section 404. No mitigation is required.	na	na	LS	na	na	na
Impact TR-16. The Vegetation Management Alternative would have a **less-than-significant** impact on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites. No mitigation is required.	na	na	LS	na	na	na
Impact TR-17. The Vegetation Management Alternative would have **no impact** on local policies or ordinances protecting terrestrial resources.	na	na	N	na	na	na
Impact TR-18. The Vegetation Management Alternative has a **less-than-significant** impact on approved HCPs or NCCPs. No mitigation is required.	na	na	LS	na	na	na

Table 5-9 Summary of Biological Resources - Terrestrial Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact TR-19. The Biological Control Alternative would have **no impact** either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species.	na	na	na	N	na	na
Impact TR-20. The Biological Control Alternative would have **no impact** on any riparian habitat or other sensitive natural community.	na	na	na	N	na	na
Impact TR-21. The Biological Control Alternative would have **no impact** on federally protected wetlands as defined by CWA Section 404.	na	na	na	N	na	na
Impact TR-22. The Biological Control Alternative would have **no impact** on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites.	na	na	na	N	na	na
Impact TR-23. The Biological Control Alternative would have **no impact** on local policies or ordinances protecting biological resources.	na	na	na	N	na	na
Impact TR-24. The Biological Control Alternative would have **no impact** on approved HCPs, NCCPs, or local conservation plans.	na	na	na	N	na	na
Impact TR-25: The Chemical Control Alternative's mosquito larvicides would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	na	na	na	LS	na
Impact TR-26: The Chemical Control Alternative's mosquito adulticides would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	na	na	na	LS	na

Table 5-9 Summary of Biological Resources - Terrestrial Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact TR-27: The Chemical Control Alternative's use of the synergist PBO would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	na	na	na	LS	na
Impact TR-28: The Chemical Control Alternative's use of pyrethrin, pyrethroids, and pyrethroid-like pesticides for yellow jacket wasp and tick control would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	na	na	na	LS	na
Impact TR-29. The Chemical Control Alternative would have **no impact** on any riparian habitat or other sensitive natural community.	na	na	na	na	N	na
Impact TR-30. The Chemical Control Alternative would have **no impact** on federally protected wetlands as defined by CWA Section 404.	na	na	na	na	N	na
Impact TR-31. The Chemical Control Alternative would have a **less-than-significant** impact on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites. No mitigation is required.	na	na	na	na	LS	na
Impact TR-32. The Chemical Control Alternative would have **no impact** on local policies or ordinances protecting terrestrial resources.	na	na	na	na	N	na
Impact TR-33. The Chemical Control Alternative would have a **less-than-significant** impact on approved HCPs, NCCPs, or local conservation plans. No mitigation is required.	na	na	na	na	LS	na
Impact TR-34. The Other Nonchemical Control/Trapping Alternative would have a **less-than-significant** impact either directly or through habitat modifications, on any terrestrial species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	na	na	na	na	LS

Table 5-9 Summary of Biological Resources - Terrestrial Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact TR-35. The Other Nonchemical Control/Trapping Alternative would have **no impact** on any riparian habitat or other sensitive natural community.	na	na	na	na	na	N
Impact TR-36. The Other Nonchemical Control/Trapping Alternative would have **no impact** on federally protected wetlands as defined by CWA Section 404.	na	na	na	na	na	N
Impact TR-37. The Other Nonchemical Control/Trapping Alternative would have **no impact** on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites.	na	na	na	na	na	N
Impact TR-38. The Other Nonchemical Control/Trapping Alternative would have **no impact** on local policies or ordinances protecting terrestrial resources.	na	na	na	na	na	N
Impact TR-39. The Other Nonchemical Control/Trapping Alternative would have **no impact** on approved HCPs, NCCPs, or local conservation plans.	na	na	na	na	na	N

LS = Less-than-significant impact

N = No impact

na = Not applicable

SM = Potentially significant but mitigable impact

SU = Significant and unavoidable impact

5.2.11 Mitigation and Monitoring

The implementation of the alternatives would not result in any significant impacts on terrestrial resources. All impacts are either less than significant or none; most assume implementation of BMPs to avoid or minimize potential impacts. Therefore, no mitigation is required.

6 Ecological Health

This chapter evaluates the potential impacts of the Program alternatives specifically on ecological health. The impact analysis relies heavily on Appendix B, *Ecological & Human Health Assessment Report*. Results of the evaluation are provided at the programmatic level. Section 6.1, Environmental Setting, presents an overview of hazards, toxicity, and exposure concepts, and contains federal, state, and local ordinances and regulations that are applicable to the Districts. Section 6.2, Environmental Impacts and Consequences, presents the following:

> Environmental concerns and evaluation criteria

> Discussion of methods and assumptions important to the environmental impact analysis

> Discussion of potential impacts of the Program alternatives

> Cumulative impacts summary

> A summary of ecological impacts

Ecological health is the integral relationship between the health and well-being of humans and the natural environment. This chapter places a particular emphasis on potential ecological receptors, in the broad sense, that may or may not be at risk from Program alternatives. Chapters 4 and 5 provide evaluations of the potential impacts to species and groups of species (nontarget organisms), as well as habitats associated with aquatic and terrestrial resources, respectively. These two chapters also address the ecological health topics covered herein. Chapter 7 evaluates the potential human health impacts related to the Program alternatives.

6.1 Environmental Setting

The Program Area is defined as the Marin/Sonoma Mosquito and Vector Control District (MSMVCD or the District) and surrounding counties including Lake, Mendocino, Napa, and Solano where the District could be asked to assist the county with control of by unwanted vectors. Earlier in this PEIR, Section 4.1 provides a description of the environmental setting for aquatic biological resources including explanations of the following components: aquatic and wetlands resources, special-status species, regulatory setting, and HCPs/NCCPs in the Program Area. Similarly, Section 5.1 provides a description of the terrestrial biological resources. The following section provides background information on the environmental fate and toxicity of pesticides and an overview of the regulatory setting with respect to chemical treatments and the use of pesticides.

6.1.1 Hazards, Toxicity, and Exposure in the Environmental Setting

A “hazardous material” is defined in California Health and Safety Code Section 25501 (p): as “any material that, because of its quantity, concentration, or physical or chemical characteristics, poses a significant present or potential hazard to human health and the environment if released into the workplace or the environment. “Hazardous materials” include, but are not limited to, “hazardous substances, hazardous waste, and any material that a handler or the administering agency has a reasonable basis for believing that it would be injurious to the health and safety of persons or harmful to the environment if released into the workplace or the environment.” Any liquid, solid, gas, sludge, synthetic product, or commodity that exhibits characteristics of toxicity, ignitability, corrosiveness, or reactivity has the potential to be considered a “hazardous material.”

Many chemicals are widely used in agriculture, commercial pest control, residential landscape/garden habitats, land management by public agencies, and vector control operations to control unwanted pests/vectors and vegetation. These chemicals are developed to effectively impact those pest/vector targets with little to no health risk. To assure the relative safety of these chemicals to humans and wildlife, commercially available chemicals are submitted to numerous laboratory tests by the chemical company, the USEPA (which has final oversight and approval), and state and international agencies to identify possible unintended adverse effects to nontarget humans and wildlife.

Risk assessments conducted to estimate potential adverse impacts to wildlife include testing and consideration of nontarget species that may be more sensitive to the chemical or have special adverse effects (i.e., endocrine disruption) than shown in the laboratory tests. The battery of tests includes birds, mammals, fish, invertebrates, reptiles, and bees. The ecological risk component usually includes evaluation of the potential for endocrine disruption and the potential for the chemical to accumulate in the exposed receptors (bioaccumulation). The product label also suggests additional procedures to minimize the potential effects to nontarget biota that may be inadvertently exposed. In the case of many chemicals, extra consideration is given to animals that may or are known to inhabit the proposed treated areas and could be inadvertently exposed. In general, this issue is addressed by several additional batteries of toxicity tests using several surrogate nontarget receptors such as beneficial insects, invertebrates, and wildlife that may be exposed via prey items.

6.1.1.1 Toxicity and Exposure

Toxicology is the study of a compound's potential to elicit an adverse effect in an organism. The toxicity of a compound is dependent upon the following:

> exposure, including the specific amount of the compound that reaches an organism's tissues (i.e., the dose)

> duration of time over which a dose is received, the potency of the chemical for eliciting a toxic effect (i.e., the response), and

> sensitivity of the organism receiving the dose of the chemical.

Toxicity effects are measured in controlled laboratory tests on a dose/response scale, in which the probability of a toxic response generally increases as the dose increases. Exposure to a compound is necessary for potential toxic effects to occur. However, exposure does not, in itself, imply that toxicity will occur in all circumstances. Thus, toxicity and adverse effects can be mitigated by limiting potential exposure to a dose less than the amount that may result in adverse health effects.

The toxicity data included in the tables and charts in this PEIR are generally derived from rigidly controlled laboratory animal studies designed to determine the potential adverse effects of the chemical under several possible routes of exposure. In these studies, the species of interest is exposed to 100 percent chemical at several doses to determine the lowest concentration resulting in a predetermined adverse effect (LOAEL) on numerous selected physiological and behavioral systems. The second component of these tests is to determine the highest concentration of chemical that results in no measurable adverse effect (NOAEL). These two levels are used to describe the potential range of exposures that could result in adverse effects, including the highest dose with no observed effects.

However, these and other coordinated and focused laboratory tests are designed to document the effects of the chemical using a continuous, controlled laboratory exposure that does not realistically reflect the likely patchy exposures typical of the District field application scenarios. As such, the toxicity information generated using laboratory tests (and some limited field tests) are intended as an overview of potential issues that might be associated with maximum direct exposures. This information is used to develop and recommend guidance for use that should provide maximum exposure levels of applications that are protective of ecological health. These guidelines include numerous "safety margins" in the toxicity

calculations that are intended to provide adequate efficacy to target organisms while not adversely impacting humans or nontarget plant and animal species. In some instances, the regulatory guidance may include additional suggestions for protective application to assure no significant adverse effect on nontarget species and humans.

The regulatory community uses this basic information to provide a relative comparison of the potential for a chemical to result in unwanted adverse effects and this information is reflected in the approved usage labels and material safety data sheets (MSDSs),[1] in actual practice, the amounts actually applied by the District within the District's Program Area for vector control are substantially less than the amounts used in the laboratory toxicity studies. Because of the large safety factors used to develop recommended product label application rates, the amount of chemical resulting in demonstrated toxicity in the laboratory is much higher than the low exposure levels associated with an actual application for vector control. The application concentrations consistent with the labels or MSDSs are designed to be protective of the health of humans and other nontarget species (i.e., low enough to not kill them, weaken them, or cause them to fail to reproduce). Although numerous precautions (BMPs) and use of recommended application guidance is intended to provide efficacy without adverse effects to nontarget organisms, misapplication or unexpected weather conditions may still result in effects on some nontarget organisms in the exposure area. This potential impact is ameliorated by careful use of BMPs and advance planning by the District.

Although laboratory toxicity testing focuses on tiered concentrations of chemical exposure, the results of these tests produce a series of toxicity estimates of concentrations less than those that produce mortality. Extrapolation of these data is used to generate estimates of chronic toxicity or possible effects of lower doses that may result in sublethal effects such as reproduction or metabolic changes. In reality, these low-dose exposures need to be sustained over longer periods than are relevant to typical application scenarios for vector control including multiple applications in an area such as a wetland.

6.1.1.2 Chemistry, Fate, and Transport

Various biological, chemical, and physical parameters affect the behavior of a compound in the environment and its potential toxicity. The chemistry, fate, and transport of a compound must be analyzed to fully estimate potential exposure. The fate and transport of a compound is determined by the physical and chemical properties of the compound itself and the environment in which it is released. Thus, the following characteristics of a compound must be evaluated: its half-life in various environmental media (e.g., sediment, water, air); photolytic half-life; lipid and water solubility; adsorption to sediments and plants; and volatilization. Environmental factors that affect fate and transport processes include temperature, rainfall, wind, sunlight, water turbidity, and water and soil pH. Information pertaining to these parameters allows evaluation of how compounds may be transported between environmental media (e.g., from sediments to biota), how a compound may be degraded into various breakdown products, and how long a compound or its breakdown products may persist in different environmental media. In general, when a compound or its breakdown products decompose rapidly in the environment and do not persist for extended periods, then the compound or product poses a lower risk to nontarget species and a lower potential for environmental pollution. Appendix B provides a discussion of the environmental fate of the pesticide active ingredients and other chemicals associated with specific pesticide formulations used in the Program alternatives.

[1] Although the MSDS format is referenced in this document, it should be noted that under the international Globally Harmonized System, the MSDS format has been substantially revised and is now largely replaced by standardized Safety Data Sheets (SDSs).

6.1.1.3 Bioaccumulation and Biomagnification

Bioaccumulation is the increase in concentration of a chemical from the environment to the first organism in a food chain, while biomagnification is the increase in concentration of a chemical from one trophic level in the food chain to another. In addition to direct exposures, the issues of bioaccumulation of some chemicals (they have all been categorized by USEPA) and their persistence in the environment are all included in the risk calculations wherever the data are available. Several chemicals are identified as persistent, meaning that they remain in the media of application for relatively long periods (i.e., weeks, months). However, most pesticides currently used by the District are selected preferentially for much shorter half-lives of hours to days. These physio/chemical characteristics of the chemicals selected for vector control are always considered early in the risk calculation process. Only in some special situations such as an USEPA Section 18 “emergency” are the older, more persistent products allowed. These emergency situations are intended for and only to stop dramatic and sometimes potentially catastrophic vector infestations.

Biologically persistent chemicals (and bioaccumulation) by definition address the potential for a chemical to move up the food chain and even increase the tissue concentration (biomagnification) in higher trophic animals. The chemicals known to elicit bioaccumulation and/or biomagnification are specifically addressed in the assessment as each of the “higher” (predator) receptor species is considered. As a result of this focus on biological and chemical properties of selected pesticides, the risk assessment process provides the best, conservative estimate of any potential unwanted adverse effects.

Some chemicals have the potential to be retained in the fatty tissues of organisms and accumulate after their prolonged exposure to contaminated sources (bioaccumulation), resulting in a higher concentration in the organism over time. In some cases chemicals can even exist in organisms above the exposure media concentrations (biomagnification). However, biomagnification is correlated with an organism that is associated with continued exposure to a contaminated environment (e.g., usually sediments and water) and is not typically associated with the chemical exposures that might result from District applications for vector control. Even chemicals that have a potential to bioaccumulate do not exhibit this phenomenon in all biota, since toxic chemicals are selectively taken up by fat (e.g., a chemical may bioaccumulate in fish but not in all animals). Many toxic substances are excreted or metabolized after ingestion such that bioaccumulation is dependent on the physio/chemical characteristics of the chemical (persistence and toxicity), the concentration of the chemical, and the specific organism exposed.

With the exception of a small number of pesticides currently used or planned for use by the District, the majority do not bioaccumulate. The herbicide adjuvants nonylphenol and short-chain nonylphenol ethoxylates are discussed in Section 6.2.5.1.2. See Section 6.2.7 under the Chemical Control Alternative for a discussion of four pesticides with potential for bioaccumulation. The persistence, bioaccumulation, and the toxicity of each of the chemicals used or planned for use by the District are presented in each of the respective sections addressing these chemicals in Appendix B and in Appendix B, Table 6-1.

6.1.2 Program Pesticides and the Environment

The pesticide and herbicide active ingredients included in the Program are listed in Table 6-1 and Table 6-2, respectively. The herbicides are used infrequently, and the District may consider additional use in the future in collaboration with other agencies for vegetation management. Appendix B provides the results of review and evaluations of the active ingredients and adjuvants the District currently uses or proposes to use.

Table 6-1 Pesticide Active Ingredients

Active Ingredient	Vector
Biodegradable Alcohol Ethoxylated Surfactant	Mosquito (larvae and pupae)
Aliphatic Solvents (e.g., mineral oil, aliphatic petroleum hydrocarbons)	Mosquito (larvae and pupae)
Methoprene	Mosquito (larvae)
Bacillus sphaericus (Bs)	Mosquito (larvae)
Bacillus thuringiensis israelensis (Bti)	Mosquito (larvae)
Spinosad	Mosquito (larvae)
Deltamethrin	Yellow jacket wasp, ticks
Tetramethrin	Yellow jacket wasp
Permethrin	Mosquito (adults)
Pyrethrins	Mosquito (adults) / yellow jacket wasp
Resmethrin	Mosquito (adults)
Phenothrin	Mosquito / yellow jacket wasp
Allethrins and d-*trans*-allethrin	Yellow jacket wasp, ticks
Prallethrin	Mosquito (adults)
Esfenvalerate	Yellow jacket wasp, tick
Etofenprox	Mosquito(adults) / yellow jacket wasp
Piperonyl Butoxide (PBO)	Mosquito (adults) / yellow jacket wasp

Table 6-2 Herbicide Active Ingredients and Adjuvants

Active Ingredient	Vector
Imazapyr	Vegetation
Glyphosate	Vegetation
Triclopyr	Vegetation
Alkyl Phenol Ethoxylates (APEs)	Vegetation
Modified Plant Oil and Methylated Seed Oil	Vegetation
Lecithin (phosphatidylcholine)	Vegetation
Aliphatic Polycarboxylate	Vegetation

6.1.3 Regulatory Setting

Formulations proposed for the Vegetation Management and Chemical Control Alternatives for vector control are and would be used according to federal and state regulatory requirements for the registration, transportation, and use of pesticides. The regulatory framework pertaining to the use of pesticides is discussed below.

6.1.3.1 Federal

The USEPA regulates pesticides under two major statutes: the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Federal Food, Drug, and Cosmetic Act (FFDCA). Under these acts, the USEPA mandates extensive scientific research to assess risks to humans, domestic animals, wildlife, plants, groundwater, and beneficial insects before granting registration for a pesticide. These studies allow the USEPA to assess the potential for human and ecological health effects. When new data raise concern about the safety of a registered pesticide, the USEPA may take action to suspend or cancel its registration. The USEPA may also perform an extensive special review of a pesticide's risks and benefits and/or work with manufacturers and users to implement changes in a pesticide's approved use (e.g., reducing application rates).

6.1.3.1.1 Federal Insecticide, Fungicide, and Rodenticide Act

FIFRA defines a pesticide as "any substance intended for preventing, destroying, repelling, or mitigating any pest." FIFRA requires USEPA registration of pesticides prior to their distribution for use in the US, sets registration criteria (testing guidelines), and mandates that pesticides perform their intended functions without causing unreasonable adverse effects on people and the environment when used according to USEPA-approved label directions. FIFRA defines an "unreasonable adverse effect on the environment" as "(1) any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of the pesticide, or (2) a human dietary risk from residues that result from a use of a pesticide in or on any food inconsistent with the standard under Section 408 of the Federal Food, Drug, and Cosmetic Act (21 USC 346a)."

FIFRA regulates only the active ingredients of pesticides, not inert ingredients, which manufacturers are not required to reveal. However, toxicity studies conducted under FIFRA are required to evaluate the active ingredient and the entire product formulation, through which any potential additive or synergistic effects of inert ingredients are established.

6.1.3.1.2 Clean Water Act and National Pollutant Discharge Elimination System

The Clean Water Act (CWA) establishes the principal federal statutes for water quality protection "to restore and maintain the chemical, physical, and biological integrity of the nation's water, to achieve a level of water quality which provides for recreation in and on the water, and for the propagation of fish and wildlife":

> Section 303(d) requires each state to provide a list of impaired waters that do not meet or are expected not to meet state water quality standards as defined by that section. The CWA regulates potentially toxic discharges through the NPDES and ambient water quality through numeric and narrative water quality standards. The release of aquatic pesticides into waters of any state may require an NPDES permit, depending on the pesticide considered, and the conditions proposed for application.

> Section 402, the NPDES, requires permits for pollution discharges (except dredge or fill material) into US waters, such that the permitted discharge does not cause a violation of federal and state water quality standards. Biological and residual pesticides discharged into surface waters constitute pollutants and require coverage under an NPDES permit. In California, NPDES permits are issued by the SWRCB or the RWQCBs.

6.1.3.1.3 California Toxics Rule

In 2000, the USEPA developed water quality criteria for priority toxic pollutants to protect human health and the environment. A gap in California's water quality standards was created when the state's water quality criteria for priority toxic pollutants were overturned in 1994 (thus, causing California to be out of compliance with the CWA). These established criteria are to be applied to inland surface waters, enclosed bays, and estuaries in California. The rule includes aquatic life criteria for 23 priority toxic pollutants, human health criteria for 57 priority toxics, and a compliance schedule.

6.1.3.1.4 Stipulated Injunction and Order, Protection of California Red-Legged Frog from Pesticides

On October 20, 2006, the US District Court for the Northern District of California imposed no-use buffer zones around California red-legged frog upland and aquatic habitats for certain pesticides. This injunction and order will remain in effect for each pesticide listed in the injunction until the USEPA goes through formal 7(A)(2) consultation with the USFWS on each of the 66 active ingredients, and the USFWS issues a Biological Opinion including a "not likely to adversely affect" statement for the pesticides. Under the injunction and order, no-use buffer zones of 60 feet for ground applications and 200 feet for aerial applications apply from the edge of the following California red-legged frog habitats as defined by the USFWS and the Center for Biological Diversity: Aquatic Feature, Aquatic Breeding Habitat, Nonbreeding Aquatic Habitat, and Upland Habitat. These habitats are found in 33 counties of California including Marin and Sonoma counties.

Of the 66 pesticides listed in the injunction, the District may employ esfenvalerate, methoprene, and permethrin for vector control. Esfenvalerate may be used for yellow jacket wasp and tick control in response to public complaints. Methoprene is used for larval mosquito control, and permethrin is may be used for adult mosquito control. However, vector control programs are exempt. Specifically, for applications of a pesticide for purposes of public health vector control under a program administered by a public entity, the injunction does not apply. The District may use the following herbicides listed in the injunction: glyphosate, imazapyr, and triclopyr. Where used for vegetation management for control of mosquito-breeding habitat, the injunction would not apply. If these herbicides were to be used for invasive species management to assist other agencies or landowners, then the injunction generally applies until such time that the material has been reviewed by USEPA and USFWS determines that it does not apply or the following "exceptions for invasive species and noxious weed programs" can be met:

> You are applying a pesticide for purposes of controlling state-designated invasive species and noxious weeds under a program administered by a public entity; and

> You do not apply the pesticide within 15 feet of aquatic breeding critical habitat or nonbreeding aquatic critical habitat within critical habitat areas, or within 15 feet of aquatic features within noncritical habitat sections subject to the injunction; and

> Application is limited to localized spot treatment using hand-held devices; and

> Precipitation is not occurring or forecast to occur within 24 hours; and

> You are a certified applicator or working under the direct supervision of a certified applicator; and

> If using 2,4-D or triclopyr, you are using only the amine formulations (USEPA 2014a).

6.1.3.2 State of California

California's programs for the registration of pesticides and commercial chemicals parallel federal programs, but many of California's requirements are stricter than federal requirements. The registration of pesticides and commercial chemicals in California is regulated by the California Environmental Protection Agency (Cal/EPA). Within the Cal/EPA, the CDPR oversees pesticide evaluation and registration through use enforcement, environmental monitoring, residue testing, and reevaluation. The CDPR works with

County Agricultural Commissioners, who evaluate, develop conditions of use, approve, or deny permits for restricted-use pesticides; certify private applicators; conduct compliance inspections; and take formal compliance or enforcement actions. The Secretary of Resources has certified California's pesticide regulatory program as meeting CEQA requirements (CDPR 2006).

California also requires commercial growers and pesticide applicators to report commercial pesticide applications to local County Agricultural Commissioners. The CDPR compiles this information in annual pesticide use reports. The CDPR's Environmental Hazards Assessment Program collects and analyzes environmental pesticide residue data, characterizes drift and other offsite pesticide movement, and evaluates the effect of application methods on movement of pesticides in air. If a pesticide is determined to be a toxic air contaminant, appropriate control measures are developed with the California Air Resources Board to reduce emissions to levels that adequately protect public health. Control measures may include product label amendments, applicator training, restrictions on use patterns or locations, and product cancellations.

6.1.3.2.1 Porter-Cologne Act and State NPDES Permitting

Under the Porter-Cologne Act (California Water Code Section 13000) the SWRCB, and the state's nine RWQCBs that it oversees, are responsible for administering federal and state water quality regulation and permitting duties.

The SWRCB oversees pesticide NPDES permitting in California according to the active ingredients in products and some formulations. Users of specific registered and approved larvicide and adulticide products are required to obtain coverage under the Statewide NPDES Permit for Biological and Residual Pesticide Discharges to Waters of the US from Vector Control Applications (SWRCB Water Quality Order No. 2012-0003-DWQ; NPDES No. CAG 990004; Vector Control Permit). Users of certain aquatic herbicides are required to obtain coverage under the Statewide General NPDES Permit for the Discharge of Aquatic Pesticides for Aquatic Weed Control in Waters of the US (SWRCB Water Quality Order No. 2004-0009-DWQ; NPDES No. CAG 990005; Aquatic Weed Control Permit). Pesticides and herbicides that require state NPDES permitting include Bti, Bs, temephos, spinosad, petroleum distillates, naled, pyrethrin, permethrin, resmethrin, prallethrin, PBO, etofenprox, 2,4-D, glyphosate, imazapyr, and triclopyr. Both permits are discussed in detail in Chapter 9, Section 9.1.2.2.9.

6.1.3.2.2 The Safe Drinking Water and Toxic Enforcement Act (Proposition 65)

This act, passed as a ballot initiative in 1986, requires the state to annually publish a list of chemicals known to the state to cause cancer or reproductive toxicity so that the public and workers are informed about exposures to potentially harmful compounds. Cal/EPA's Office of Environmental Health Hazard Assessment administers the act and evaluates additions of new substances to the list. Proposition 65 requires companies to notify the public about chemicals in the products they sell or release into the environment, such as through warning labels on products or signs in affected areas, and prohibits them from knowingly releasing significant amounts of listed chemicals into drinking water sources.

6.1.3.2.3 California Pesticide Regulatory Program

CDPR regulates the sale and use of pesticides in California. CDPR is responsible for reviewing the toxic effects of pesticide formulations and determining whether a pesticide is suitable for use in California through a registration process. Although CDPR cannot require manufacturers to make changes in labels, it can refuse to register products in California unless manufacturers address unmitigated hazards by amending the pesticide label. Consequently, many pesticide labels that are already approved by the USEPA also contain California-specific requirements. Pesticide labels defining the registered applications and uses of a chemical are mandated by USEPA as a condition of registration. The label includes instructions telling users how to make sure the product is applied only to intended target pests, and includes precautions the applicator should take to protect human health and the environment. For

example, product labels may contain such measures as restrictions in certain land uses and weather (i.e., wind speed) parameters.

6.2 Environmental Impacts and Mitigation Measures

This section evaluates the potential ecological impacts from the Program alternatives, which is primarily focused on the use of active ingredients in herbicides and/or pesticides under the Vegetation Management and Chemical Control Alternatives.

6.2.1 Evaluation Concerns and Criteria

The public has requested that the PEIR evaluate the following issues and concerns related to ecological health, which were identified during the project scoping process. These concerns are addressed briefly below and in this chapter. While not required, the responses to the concerns help to direct the reader to the appropriate section or an appendix, or they provide explanatory information in concise form.

> What are the impacts associated with the Surveillance Alternative?

- The impacts to ecological health are addressed briefly in Section 6.2.3. The question was meant to address CDFW's concern that biological impacts be addressed by habitat type. This type of analysis was conducted for aquatic biology in Chapter 4 and for terrestrial biology in Chapter 5. The discussion herein is at a programmatic level for the broad issue of environmental disturbance from people and equipment in conducting surveillance and monitoring activities.

> Describe the effects of all chemicals that are used and/or proposed for use on wildlife and natural ecosystems, including insect prey, birds, mammals, fish, vegetation, and site topography. The loss of prey for birds is a particular concern.

- The toxicity of the active ingredients and adjuvants is evaluated in Appendix B, and select pesticides are discussed in Section 6.2.7, including an evaluation of the major classes of active ingredients and potential impacts to nontarget ecological receptors.

> Discuss the potential impact of *Bacillus sphaericus* (Bs is a bacterium whose spores can persist in the environment for several weeks to months) on native species. What would justify its use? What native species would be impacted?

- Bs is a naturally occurring soil bacterium. Data indicate a high degree of specificity with Bs (and Bti) for mosquitoes and demonstrate no toxicity to chironomid larvae at any mosquito control application rate. Bs is capable of cycling in the aquatic environment providing weeks of effective mosquito control after a single dose. It is very effective in water with high organic content and limited efficacy in brackish and saline waters. The use, fate and transport, and potential toxicity of Bs is discussed in Section 6.2.7 and described in detail in Appendix B.

> Discuss impacts on bees from chemicals in treatment applications.

- Potential impacts on nontarget receptors, including bees, are discussed in Section 6.2.7 and Appendix B.

> Concern over the "inactive" portion of the pesticides. What effects will the carrier portion of the chemicals have on the environment?

- FIFRA primarily regulates active ingredients; however, the toxicity studies performed under FIFRA also may evaluate the entire product formulation. Cal/EPA and CDPR have approved the inactive ingredients in the Mosquito Vector Control Association of California's formulations in the NPDES permit. Thus, the potential additive or synergistic effect of inert ingredients is addressed through required laboratory testing protocols, which is beyond the scope of this PEIR.

> Discuss the effects of pesticides on the natural predators of mosquitoes.

- As part of its IVMP, the District uses pesticides with high mosquito specificity and low toxicity to nontarget species whenever possible. The District also strictly adheres to labeling requirements supplemented with the use of strict BMPs to avoid nontarget species exposure. Additional information on natural predators of mosquitoes is contained in Appendix E, *Alternatives Analysis Report*.

> The continued spray program leads to survival of mosquitoes resistant to pesticides – "the pest mill."

- The IVM approach the District uses to control mosquitoes is designed to minimize the potential for resistance to pesticides in the Program Area. Using this approach, the District implements the following practices: vegetative and biological control of mosquito populations, use of pesticides only when necessary, specific and localized applications, ULV applications, use of pesticides with low persistence, and rotation of pesticides.

> Describe the role of mosquitoes within the food chain, and subsequent impacts if they were removed in terms of amphibians, birds, reptiles, fish, and insects.

- Although larval and adult mosquitoes serve a role as potential prey items for some invertebrates, fish, avian insectivores, bats, small reptiles, and amphibians, the loss or reduction of a focus area (population of mosquitoes) will not affect the predator populations overall. Many species of mosquitoes are short lived or seasonal, so they generally serve as only one or many possible prey sources for predators. The decline in one prey species generally means that a predator will shift its food preference. No predators are known that must rely exclusively on mosquitoes (larval or adult) for prey.

> Upon application and broadcast of pesticides, what is the fate and transport of these chemicals? Look at droplet size, dispersal patterns given wind, conversion products (both in storage and environment), and impacts of conversion products. Discuss the persistence of proposed treatment substances in the environment as well as the potential for bioaccumulation.

- The use, fate, and transport of each pesticide included in the Program are described in detail in Appendix B, and results are incorporated into the environmental impact analyses in this chapter. Most products sold as herbicides and pesticides are evaluated both for the active ingredient and for the adjuvants and surfactants used to make the product more useful. When multiple products are used in a vector control treatment, the impacts are weighed against the proximity and timing of each application. If products with a similar or different active ingredient are applied simultaneously, it is likely that the net effect could be the sum of the total active ingredient that is available for uptake by the vector. Although a synergy is possible in this scenario, it is typically not an approach used in or directed by the BMPs for that scenario. Because most pesticides and herbicides now in use have considerably less half-life (persistence) than earlier formulations, the overlap that would produce a residual exposure to a product would not occur unless the timing of applications is inappropriately close, i.e., hours rather than several days apart. Actual applications do not generally occur that close together. Many products can be evaluated for synergy and potential additive effects using the CDPR templates for calculation, which provide a means of estimating the potential effects of multiple chemicals used in one application.

> The PEIR should include monitoring programs that are designed to validate assumptions regarding the environmental fate and transport of materials.

- The Surveillance Alternative is described in Section 6.2.3. Mitigation and monitoring is described in Section 6.2.11; the District also conducts surveillance and monitoring of treatment results on a routine basis. Additional monitoring programs are beyond the scope of the PEIR and not needed based on information that suggests that the Program would not have a significant adverse effect on biological resources. See Appendix B for fate and transport information on the materials considered for use under the District's IVMP. However, District staff will monitor sites post-treatment to

determine if the target vector or target vegetation was effectively controlled with minimum effect to the environment and nontarget organisms. This information will be used to help design future treatment methods in the same season or future years to respond to changes in site conditions.

> The PEIR should include a detailed description and complete assessment of the chemical control impacts (current and future, direct and indirect) on habitats (including endangered, threatened, and locally unique species and sensitive habitats) and on species (sensitive fish, wildlife, or plants) and ensure CEQA requirements are met.

- Potential chemical control impacts are discussed in Section 6.2.7 and Appendix B. Potential impacts to special-status aquatic and terrestrial species are discussed in Chapters 4 and 5, respectively which both address the HCP and NCCP activities in the Program Area

> The PEIR should include a detailed description and complete assessment of the biological control impacts (current and future, direct and indirect) on habitats (including endangered, threatened, and locally unique species and sensitive habitats) and on species (sensitive fish, wildlife, or plants) and ensure CEQA requirements are met.

- Potential biological control impacts are discussed in Section 6.2.6 (mosquitofish), and biologically based pathogens (the mosquito larvicides Bs, Bti, and spinosad) are discussed in Section 6.2.7.1 and Appendix B. Potential impacts to special-status aquatic and terrestrial species are discussed in Chapters 4 and 5, respectively.

The CEQA Guidelines Appendix G, *Environmental Checklist Form*, does not contain criteria for determining significance of impacts to ecological health from the use of pesticides and herbicides. The closest criteria are those contained in Section 4.2.1.2 for biological resources. In short, the determination of significance is based on the potential to degrade the quality of the environment for natural communities and the species therein based on existing data and application methods. The specific concern is whether the activities used to control vectors could result in direct or indirect impacts to other organisms that may be present which are called nontarget ecological receptors.

6.2.2 Evaluation Methods and Assumptions

Pesticides the District uses were investigated to provide an assessment of the potential impacts to nontarget ecological receptors.

6.2.2.1 Evaluation Methods

An ecological health assessment was the principal method used to evaluate concerns associated with the Program alternatives (discussed in detail in Appendix B). A comprehensive literature review of published toxicity and fate and transport information was conducted. In addition, the District supplied information specific to pesticide and herbicide product use in the Program Area to support the potential exposure and toxicity assessment. Information collected included the following:

> Pesticides the District uses or may use

> Pesticide label requirements

> Types of application sites (e.g., habitat types)

> Application procedures

> Estimated applications and sites

> Estimated total amount used per quarter

> Physicochemical properties of the pesticides/active ingredients

> Pesticide target vector efficacy

> Reported adverse effects (e.g., reproductive, developmental, carcinogenic).

Pesticides identified as warranting further evaluation in Appendix B are known to exhibit at least one parameter that appears to exhibit a potential or perceived risk. Toxicity levels (e.g., slight, low, moderate, high, etc.) are used prevalently in the published literature but are not uniformly standardized or representative of specific criteria. They qualitatively describe toxicity in relative terms in the evaluations of herbicides and pesticides in this PEIR and in Appendix B. Toxicity levels are helpful in making significance determinations under CEQA.

The pesticide application scenarios that result in reasonable efficacy with minimal unwanted estimated risk are preferred and are the basis of IVM approaches and BMPs the District employs. All BMPs are listed comprehensively as part of the Proposed Program in Chapter 2 (Table 2-6), and relevant ones to ecological health are repeated below.

For all six Program alternatives, the District uses the following BMPs:

> District staff will implement site access selection criteria to minimize equipment use in sensitive habitats including active nesting areas and to use the proper vehicles for onroad and offroad conditions. (BMP A9)

> Properly train all staff, contractors, and volunteer help to prevent spreading weeds and pests to other sites. The District headquarters contains wash rack facilities (including high-pressure washers) to regularly (in many cases daily) and thoroughly clean equipment to prevent the spread of weeds. (BMP A10)

For five of the Program alternatives, excluding Biological Control's use of mosquitofish, the District uses the following BMPs:

> District staff will work with care and caution to minimize potential disturbance to wildlife while performing surveillance and vector treatment/population management activities. (BMP A6)

> Vehicles driving on levees to travel through tidal marsh or to access sloughs or channels for surveillance or treatment activities will travel at speeds no greater than 10 miles per hour to minimize noise and dust disturbance. (BMP A8)

> The District will minimize the use of equipment (e.g., ARGOs) in tidal marshes and wetlands. When feasible and appropriate, surveillance and control work will be performed on foot with handheld equipment. Aerial treatment (helicopter and fixed-wing) treatments will be used, when feasible and appropriate, to minimize the disturbance of the marsh during pesticide applications. When ATVs (e.g., ARGOs) are used, techniques will be employed that limit impacts to the marsh, including slow speeds; slow, several point turns; using existing levees or upland to travel through sites when possible; using existing pathways or limiting the number of travel pathways used. (BMP B2)

> District staff will minimize the potential for the introduction and spread of spartina, perennial pepperweed, and other invasive plant species by cleaning all equipment, vehicles, personal gear, clothing, and boots of soil, seeds, and plant material prior to entering the marsh, and avoiding walking and driving through patches of perennial pepperweed to the maximum extent feasible. (BMP B4)

For four of the Program alternatives, excluding Biological Control and Other Nonchemical Control/Trapping Alternatives, the following BMPs apply:

> Identify probable (based on historical experience) treatment sites that may contain habitat for special-status species every year prior to work to determine the potential presence of special-status flora and fauna using the CNDDB, relevant HCPs, NOAA Fisheries and USFWS websites, CAlfish.org, and other biological information developed for other permits. Establish a buffer of reasonable distance, when feasible, from known special-status species locations and do not allow application of pesticides/herbicides within this buffer without further agency consultations. Nonchemical methods are

acceptable within the buffer zone when designed to avoid damage to any identified and documented flora and fauna. (BMP A7)

> District will minimize travel along tidal channels and sloughs to reduce impacts to vegetation used as habitat (e.g., Ridgway's rail nesting and escape habitat). (BMP B3)

For Vegetation Management and Chemical Control Alternatives only, the following BMPs apply:

> District staff will conduct applications with strict adherence to product label directions that include approved application rates and methods, storage, transportation, mixing, and container disposal. (BMP H1)

> District will avoid use of surfactants when possible in sites with aquatic nontargets or natural enemies of mosquitoes present such as nymphal damselflies and dragonflies, dytiscids, hydrophilids, corixids, notonectids, and ephydrids. Surfactants are the only tool used to treat sources of pupae to prevent adult mosquitos' emergence. The District will use a microbial larvicide (Bti, Bs) or insect growth regulator (e.g., methoprene) instead or another alternative when possible. (BMP H2)

> Materials will be applied at the lowest effective concentration for a specific set of vectors and environmental conditions. Application rates will never exceed the maximum label application rate. (BMP H3)

> To minimize application of pesticides, application of pesticides will be informed by surveillance and monitoring of vector populations. (BMP H4)

> District staff will follow label requirements for storage, loading, and mixing of pesticides and herbicides. Handle all mixing and transferring of herbicides within a contained area. (BMP H5)

> Postpone or cease application when predetermined weather parameters exceed product label specifications, when wind speeds exceed the velocity as stated on the product label, or when a high chance of rain is predicted and rain is determining factor on the label of the material to be applied. (BMP H6)

> Applicators will remain aware of wind conditions prior to and during application events to minimize any possible unwanted drift to waterbodies, and other areas adjacent to the application areas. (BMP H7)

> Spray nozzles will be adjusted to produce larger droplet size rather than smaller droplet size. Use low nozzle pressures where possible (e.g., 30 to 70 pounds per square inch). Keep spray nozzles within a predetermined maximum distance of target weeds (e.g., within 24 inches of vegetation for hand application) or vectors. Adjusting droplet size would only apply to larvicides, herbicides, and non-ULV applications. Use ULV applications that are calibrated to be effective and environmentally compatible at the proper droplet size (about 10-30 microns). (BMP H8)

> Clean containers at an approved site and dispose of at a legal dumpsite or recycle in accordance with manufacturer's instructions if available. (BMP H9)

> Special-Status Aquatic Wildlife Species (BMP H10):

  - A CNDDB search was conducted in 2012 and the results incorporated into Appendix A, *Biological Resources Technical Report*, for this PEIR. An update was completed in November 2014 and the results incorporated into Section 4.1.2 of this PEIR. District staff communicates with state, federal, and county agencies regarding sites that have potential to support special-status species. Staff has visited many sites where the District performs surveillance and control work for many years and staff is highly knowledgeable about the sites and habitat present. If new sites or site features are discovered that have potential habitat for special-status species, the appropriate agency or landowner is contacted and communication initiated.

  - Use only pesticides, herbicides, and adjuvants approved for aquatic areas or manual treatments within a predetermined distance from aquatic features (e.g., within 15 feet of aquatic features). Aquatic features are defined as any natural or man-made lake, pond, river, creek, drainage way, ditch, spring, saturated soils, or similar feature that holds water at the time of treatment or typically becomes inundated during winter rains.
  - If suitable habitat for special-status species is found, including vernal pools, and if aquatic-approved pesticides, herbicides, and adjuvants treatment methods have the potential for affecting the potential species, then the District will coordinate with the CDFW, USFWS, and/or NMFS before conducting treatment activities within this boundary or cancel activities in this area. If the District determines no suitable habitat is present, treatment activities may occur without further agency consultation.

> District staff will monitor sites post-treatment to determine if the target vector or weeds were effectively controlled with minimum effect to the environment and nontarget organisms. This information will be used to help design future treatment methods in the same season or future years to respond to changes in site conditions. (BMP H11)

> Do not apply pesticides that could affect insect pollinators in liquid or spray/fog forms over large areas (more than 0.25 acre) during the day when honeybees are present and active or when other pollinators are active. Preferred applications of these specific pesticides are to occur in areas with little or no honeybees or pollinator activity or after dark. These treatments may be applied over smaller areas (with handheld equipment), but the technician will first inspect the area for the presence of bees and other pollinators. If pollinators are present in substantial numbers, the treatment will be made at an alternative time when these pollinators are inactive or absent. (BMP H12)

> The District will provide notification to the public (24 to 48 hours in advance, if possible) and/or appropriate agency(ies) when applying pesticides or herbicides for large-scale treatments that will occur in close proximity to homes, heavily populated, high traffic, and sensitive areas. The District infrequently applies or participates in the application of herbicides in areas other than District facilities. (BMP H13)

> Exercise adequate caution to prevent spillage of pesticides during storage, transportation, mixing, or application of pesticides. Report all pesticide spills and cleanups (excepting cases where dry materials may be returned to the container or application equipment). (BMP I1)

Several BMPs in Table 2-6 apply primarily to the Physical Control Alternative. Key BMPs include the following for avoiding or minimizing impacts to ecological health:

> All maintenance work will be done at times that minimize adverse impacts to nesting birds, anadromous fish, and other species of concern, in consultation with USFWS, NMFS, and CDFW. Work conducted will, whenever possible, be conducted during approved in-water work periods for that habitat, considering the species likely to be present. For example, tidal marsh work will be conducted between September 1 and January 31, where possible, and not contraindicated by the presence of other special-status species. Similarly, in-water work in waterbodies that support anadromous fish will be conducted between July 1 and September 30. (BMP G3)

> Care will be taken to minimize the risk of potential disruption to the indigenous aquatic life of a waterbody in which ditch maintenance is to take place, including those aquatic organisms that migrate through the area. (BMP G4)

6.2.2.2 Assumptions

This evaluation assumes that all pesticides are applied in accordance with product label instructions and USEPA and CDPR requirements (and in consideration of the local context for that area, i.e., nearby area land uses and habitats). The USEPA requires mandatory statements to be included on pesticide product labels that include directions for use; precautions for avoiding certain dangerous actions; and where, when, and how the pesticide should be applied. This guidance is designed to ensure proper use of the pesticide and prevent unreasonable adverse effects to humans and the environment. All pesticide labels are required to include the name and percentage by weight of each active ingredient in the product/formulation. Toxicity categories for product hazards and appropriate first aid measures must be properly and prominently displayed. Pesticide labels also outline proper use, storage, and disposal procedures, as well as precautions to protect applicators. The directions for use indicate listing of the target organism, appropriate application sites, application rates or dosages, contact times, and required application equipment for the pesticide. Warnings regarding appropriate wind speeds, droplet sizes, or habitats to avoid during application are also prominently displayed.

This evaluation does not include assumptions about which alternative treatment strategy(ies) would be applied in any given area. Guidelines used to trigger a particular alternative based on vector abundance and other variables are included in the District's operating procedures. This PEIR evaluation assumes that important parameters, such as soil or sediment half-life, are dependent on the specific conditions at the time of pesticide application, and values listed herein serve as references values.

Concerning the application of multiple chemical treatments in the same area, such as larvicides followed by adulticides, or the application of multiple pesticides at the same time in a specific area, the following information applies:

> Most products sold as herbicides and pesticides are evaluated herein both for the active ingredient and for the adjuvants and surfactants used to make the product more useful. When multiple products are used in a vector control application, the impacts are weighed against the proximity and timing of each application. When two approved products are used that contain two active ingredients, this scenario is possible, but the product usually already contains two active ingredients. If products with similar or even different active ingredients are applied simultaneously, it is likely that the net effect could be the sum of the effects of the active ingredients to impact the vector. However, for vector control applications materials with the same active ingredient are not applied to the same specific area simultaneously at a given site. The need for reapplication of mosquito larvicides or adulticides is surveillance driven and performed per the label directions. The District can apply larvicide materials with different active ingredients during a single application. This type of application is necessary if multiple hatches of mosquito larvae occur and results in mosquito populations occurring at different stages of the life cycle. An example of this occurs when liquid Bti and methoprene are applied simultaneously. When this occurs the combination of the material is a product called Duplex, and the mixture of the materials and active ingredients is provided for on the product labels. Another example, for the District includes a pre-application of a liquid trans allethrin and phenothrin spray product may be used to minimize the hazard of approaching a yellow jacket nest. Situations that would produce a residual exposure adequate to cause harm to humans would not occur unless the application(s) were inappropriate or the timing of applications is inappropriately close. Actual applications do not generally occur that close together unless there is a problem with treatment effectiveness. A material is applied followed by post treatment inspection to determine effectiveness. Only if the vectors (mosquitoes) have not been sufficiently killed would the District go back into the area and reapply a pesticide.

This environmental impact evaluation also does not include an analysis of impacts to specific food webs. While it is important to evaluate the potential adverse impacts of a pesticide application to potentially affected nontarget species, it is not practical to evaluate those potential impacts to all of the food webs present in the various ecosystems under consideration. An ecological food web is represented in the illustration representing some of the multitude of possible biotic and food uptake interactions in an ecosystem. Figure 6-1 depicts a highly simplified food web. In an ecological system, each level in the food web is occupied by dozens or hundreds of species, with consumers using those resources (in this case species from a lower trophic level) in different ways depending on availability and competition for those resources. Their utilization of these resources shifts by time of day and season, and multiple resources being used simultaneously or alternatively. If the availability of one resource deceases, the consumer can generally replace that with another resource. Each of the possible connections between species is also associated with other interactions, such as competitive release, where the abundance of a species increases in response to the decline in a competitor's abundance, or competitive interactions between consumers where one consumer can use a particular resource better than its competitor.

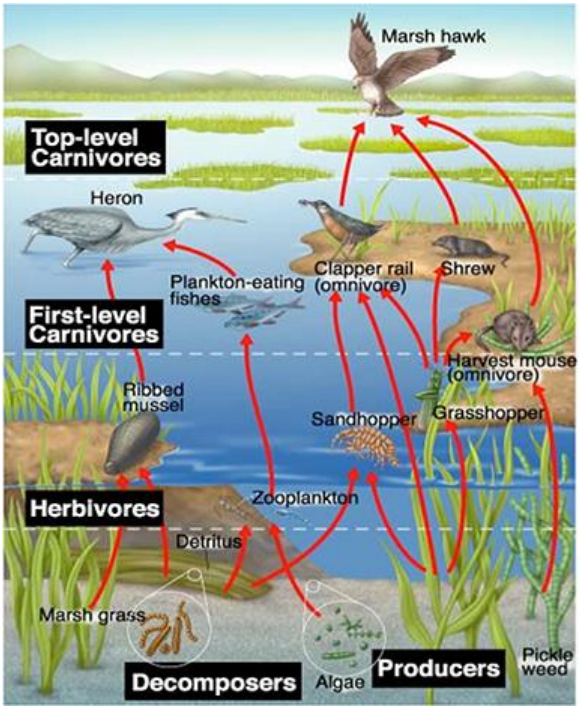


Figure 6-1 Ecological Food Web Concept

Although ecological food webs could be used to describe the complex system interactions that might be associated with District pesticide application scenarios, it is neither feasible nor practical to evaluate those potential impacts using a food-web approach. The numerous interactions in typical food webs are highly complex and would be subject to substantial uncertainty, making it exceedingly difficult to confidently assess relevant impacts. Because of these constraints and complexity, it would be neither practical nor productive to attempt to predict food-web interactions for each of the numerous application scenarios the District uses. It is appropriate, however, to use a food-web analysis to identify and consider the first level of potentially adverse effects to nontarget species that might result from a pesticide application. This information is used to assure a minimal impact to nontarget species and is typically a part of the MSDS and Toxicology profiles, providing the basis for the more reasonable, technically feasible approach to consider the possible nontarget impacts prior to use and the compatibility of each proposed pesticide in the overall approach to the typical vector control by the District.

6.2.3 Surveillance Alternative

Vector surveillance is critical to IVM strategies because it provides information that is used to determine when and where to institute other vector control measures. The District's mosquito surveillance activities are conducted in compliance with accepted federal and state guidelines (e.g., *California Mosquito-Borne Virus Surveillance & Response Plan* [CDPH et al. 2013] and *Best Management Practices for Mosquito Control in California* [CDPH and MVCAC 2012]) contained in Appendix F, *Supplemental IVMP Information*. These guidelines allow for some reasonable flexibility in selection and specific application of control methods because local areas vary.

The Surveillance Alternative would be a continuation of existing activities using applicable techniques, equipment, vehicles, and watercraft. Surveillance activities involve monitoring the abundance of adult and

larval mosquitoes, field inspection of mosquito habitat, testing for the presence of SLE, WEE, and WNV antibodies in sentinel chickens or wild birds, collection and testing of ticks, small rodent (i.e., primarily rats and mice) trapping, and/or response to public service requests regarding nuisance animals or insects (e.g., yellow jacket wasps).

Small impacts to terrestrial and aquatic habitats could occur when the District is required to maintain paths and clearings to access surveillance sites and facilitate sampling. A number of the BMPs listed in Section 6.2.2.1 above apply to surveillance activities to minimize disturbance to habitats and the species present or potentially present from the use of equipment and walking by District biologists and technicians to obtain samples.

Trapping activities conducted to assess the presence and abundance of rodent populations could lead to capture and mortality of nontarget organisms. The District uses preexisting roads, trails, and walkways for most surveillance activities. Therefore, habitat disturbance is minimal to negligible, reducing the potential indirect impacts to nontarget species and their habitat. Trapping to assess rodent presence and abundance is infrequently conducted to reduce the chance of nontarget species capture.

> **Impact ECO-1:** The Surveillance Alternative would have a **less-than-significant** impact on nontarget ecological receptors, including native or special-status plants and animals and mitigation is not required.

6.2.4 Physical Control Alternative

The Physical Control Alternative would be a continuation of existing activities using applicable techniques, equipment, vehicles, and watercraft. Physical control for mosquitoes consists of the management of mosquito-producing habitat (including freshwater marshes and lakes, saltwater marshes, temporary standing water, and wastewater treatment facilities) especially through water control and maintenance or improvement of channels, tide gates, levees, and other water control facilities. Physical control is usually the most effective mosquito control technique because it provides a long-term solution by reducing or eliminating mosquito developmental sites and ultimately reduces the need for chemical applications. Physical control practices may be categorized into three groups: maintenance, new construction, and cultural practices. The District performs these physical control activities in accordance with all appropriate environmental regulations (wetland fill and dredge permits, endangered species review, water quality review, streambed alteration permits), and in a manner that generally maintains or improves habitat values for desirable species. Physical control for other vectors such as rodents is based on District site inspections to determine conditions promoting infestation, and property owners are provided educational materials on control measures that include information about the removal of food sources and harborage sites and professionals to contact to remove the infestation. For physical control measures used for onsite wastewater treatment systems, see Section 9.2.4.

The Physical Control Alternative would not likely result in measurable adverse impacts to ecological receptors, including terrestrial and aquatic species. This alternative employs physical modifications to the natural and engineered environment providing a long-term solution to mosquito control while reducing the dependence on chemical controls. In addition, these practices are conducted to improve habitat for desirable species, such as native and special-status plants and animals. Chapter 4 discusses in greater detail the potential impacts of the Physical Control Alternative on aquatic resources, including special-status species. Chapter 5 discusses impacts to terrestrial resources.

The District employs a number of BMPs when implementing actions under the Physical Control Alternative. For example, all ditch maintenance work will be done at times that minimize adverse impacts to nesting birds, anadromous fish, and other species of concern, in consultation with USFWS, NMFS, and CDFW. As well as the BMPs listed herein in Section 6.2.2.1, the District implements additional BMPs to avoid or minimize impacts to the marsh-specific plants and animals, the salt marsh harvest mouse, Ridgway's rail, and soft bird's beak (see Table 4-6). The District performs these activities in accordance

with all appropriate environmental regulations and in a manner that generally maintains or improves habitat for desirable species. Most of these activities occur in aquatic rather than terrestrial habitats. District staff communicates with state, federal, and county agencies regarding sites (aquatic, terrestrial, and temporary habitats [e.g., vernal pools]) that have potential to support special-status species. Many sites where the District performs source control work have been visited by staff for many years, and staff is intimately knowledgeable about the sites and habitat present. If new sites or site features are discovered that have potential habitat for special-status species, the appropriate agency or landowner is contacted and communication initiated. Vernal pools can provide breeding habitat for mosquitoes but also provide habitat for many special-status species in California. Therefore, destruction or impairment of vernal pool habitat is avoided under the Physical Control Alternative. The presence of special-status species at aquatic or terrestrial sites or the presence of suitable habitat for special-status species would result in cancellation or strategic planning with other agencies to perform work at a time or in a manner that does not negatively impact habitat or special-status species.

> **Impact ECO-2:** The Physical Control Alternative would have a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.

6.2.5 Vegetation Management Alternative

The Vegetation Management Alternative would be a continuation of existing activities using applicable techniques, equipment, vehicles, and watercraft. Vegetation management (including noxious weeds and/or invasive plants) is conducted to facilitate access to vector habitat, improve efficiency and effectiveness of mosquito control operations, and as a source reduction measure.

The District uses hand tools (e.g., shovels, pruners, chain saws, and weed-whackers) and heavy equipment where necessary for vegetation removal or thinning and may apply herbicides to improve surveillance or reduce vector habitats. Vegetation removal or thinning primarily occurs in aquatic habitats to assist with the control of mosquitoes and in terrestrial habitats to help with the control of other vectors. To reduce the potential for mosquito breeding associated with water retention and infiltration structures, District staff may systematically clear weeds and other obstructing vegetation in wetlands and retention basins (or request the structures' owners to perform this task). Pre-project planning such as, surveys for special-status plants, coordination with the landowner, and acquisition of necessary permits are completed before any work is undertaken by the District. The District also encourages landowners to coordinate with regulatory agencies regarding necessary permits required for work they may perform. In some sensitive habitats and/or where special-status species concerns exist, vegetation removal and maintenance actions would be restricted to those months or times of the year that minimize disturbance/impacts. Vegetation management is also performed to assist other agencies and landowners with the management of invasive and/or nonnative vegetation. These actions are typically performed under the direction of the concerned agency, which also maintains any required permits.

Vegetation management in the form of physical removal could include the use of weed-whackers, chain saws, and shovels. These activities are conducted with a pre-planning understanding of the possible location of onsite and near-by special-status terrestrial plants and animals. The District applies BMPs to reduce potential impacts, including the identification of special-status species in treatment areas prior to commencing vegetation removal actions. The nonherbicide component of the Vegetation Management Alternative is not expected to result in adverse ecological effects. These activities are generally coordinated with and monitored by public agencies and conducted during times to alleviate potential impacts to nontarget organisms.

> **Impact ECO-3:** The employment of a nonherbicide Vegetation Management Alternative in the form of physical removal would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.

The District infrequently applies herbicides in collaboration with other agencies and may apply herbicides in conjunction with source reduction and/or site access in the future. Table 6-3 presents the herbicides the District may consider for future use for vegetation management, as well as the section of Appendix B where they are described in detail.

Table 6-3 Herbicide Control Options for Vegetation Management

Active Ingredient/Adjuvant	Appendix B
Imazapyr	Section 4.6.1
Glyphosate*	Section 4.6.2
Triclopyr	Section 4.6.3

*Identified for further evaluation in Appendix B and described below.

The District may consider using selected herbicides in the future to control vegetation in and around mosquito habitats to improve surveillance and reduce suitable breeding habitats. Herbicides are typically classified into the following major categories: pre-emergent herbicides (applied to the soil to prevent seedlings from germinating and emerging; post-emergent herbicides (applied after seedlings have emerged and control actively growing plants via contact damage or systemic impacts); contact herbicides (cause physical injury to the plant upon contact); and systemic herbicides (damage the internal functioning of the plant). Herbicides that may be integrated into the Program have diverse chemical structures, act through distinct modes of action, and exhibit varying levels of potential toxicity to humans and nontarget species. Certain herbicides are nonselective and broad-spectrum (e.g., imazapyr) and generally function by inhibiting growth. Herbicides used against annual broadleaf weeds are generally of the post-emergent variety, such as triclopyr. In addition, imazapyr, is a systematic, nonselective, pre- and post-emergent herbicide used for a broad range of terrestrial and aquatic weeds. Glyphosate represents a commonly used herbicide for the control and elimination of grass weeds and sedges. Most of the herbicides are moderately persistent in soil and water (for each herbicide's half-life in soil and water, please refer to Appendix B).

Herbicides the District may consider for future use are characterized by different modes of action against target vegetation and, therefore, may exhibit unique toxicity to nontarget species, including aquatic and terrestrial organisms (see Appendix B for further details regarding toxicity and fate and transport characteristics of Program herbicides). Certain herbicides may exhibit toxicity to some nontarget ecological receptors. Although no risks exist of concern to terrestrial birds, mammals, and bees or aquatic invertebrates and fish, imazapyr may pose an ecological risk to nontarget terrestrial and aquatic vascular plants (USEPA 2006b).

The District would apply BMPs to minimize the impact of herbicides on ecological receptors, including nontarget special-status terrestrial plants. In particular, the District takes action to minimize drift of sprays to nontarget areas, which is accomplished by carefully considering weather variables such as wind velocity and direction and chance of precipitation. To prevent potential impacts to aquatic systems, applications are conducted when wind is below 5 mph, the spray is carefully directed to the target vegetation, and when an adequate buffer to water sources is maintained. Typically, herbicide application does not occur within 15 feet of a crop or sensitive habitat, e.g., a winery waste/treatment plant pond as the treatment area with sensitive habitat nearby.

> **Impact ECO-4**: The use of any of the selected herbicides as a vegetation management technique would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.

The majority of herbicides under consideration exhibit little to no toxicity to mammals, birds, and terrestrial invertebrates (see Chapter 5). See Chapter 4 for a discussion of potential impacts to aquatic receptors.

When the District was investigating herbicides for use in its IVMP, glyphosate was identified for further evaluation based on use patterns and toxicity (Appendix B) and is discussed in further detail below.

6.2.5.1.1 Glyphosate

Glyphosate is a nonselective, post-emergent, and systemic herbicide registered for use in agricultural and nonagricultural areas. Currently, the District periodically uses glyphosate. Although some recent concerns have been expressed about possible sublethal effects of glyphosate products, it is virtually nontoxic to mammals and practically nontoxic to birds, fish, and invertebrates. USEPA has identified glyphosate as a candidate for evaluation as a potential endocrine disruptor (USEPA 2009a); see Section 7.2.5.1 for more on this issue and human health. Claims that glyphosate is destroying bee and butterfly populations have not been substantiated. The use of glyphosate to control milkweed, which is a severe problem for farmers, may be connected to loss of foraging vegetation and, thereby, indirectly impacting butterfly populations. However, this effect is an indirect effect and not actually toxicity to the butterflies. Every effort is also made to minimize treatments that could affect milkweed, a plant important to Monarch butterfly populations.

Although at low treatment levels glyphosate has been shown to be essentially nontoxic to mammals and humans; based on ancillary issues it is likely that USEPA may provide an updated review of its potential risks in 2015. In contrast to these other issues, the USEPA has recently renewed the approval of a glyphosate and 2-4-D combination product for use for unwanted vegetation. This additional supporting information indicates that USEPA has not received significant data to negate the decision (USEPA 2014a). Glyphosate products are effective, low risk products widely used for control of unwanted vegetation (Gertsberg 2011). Some reports in the press of sublethal effects on disease resistance, biological diversity, or enzyme activity, as a result of ingestion/uptake of genetically engineered foods are interesting but without clear mechanisms that can be related directly to glyphosate (Gertsberg 2011).

The District strictly adheres to its BMPs and product label requirements, including the restriction of glyphosate application to target areas outside an approved (by USFWS) or other commonly used buffer zone separating the treatment from water sources, which reduces the potential for impacts to special-status species or other nontarget receptors. It is further mediated by the techniques used for application. Typically, spraying does not occur when wind is 5 mph or greater or within 15 feet of a crop area or sensitive habitat. Targeted, small-scale treatments are conducted to minimize post-application drift and runoff.

> **Impact ECO-5:** The use of glyphosate would result in a **less-than-significant impact** to nontarget ecological receptors and mitigation is not required.

6.2.5.1.2 Adjuvants

An adjuvant is any compound that is added to a pesticide formulation (including herbicides) or tank mix to facilitate the mixing, application, or effectiveness of that pesticide/herbicide. Adjuvants can either enhance activity of an herbicide's active ingredient (activator adjuvant) or offset any problems associated with spray application, such as adverse water quality or wind (special purpose or utility modifiers). Activator adjuvants include surfactants, wetting agents, sticker-spreaders, and penetrants. Adjuvants that may be considered for future use for mosquito habitat control and weed control are presented in Table 6-4. The environmental fate and toxicity of these adjuvants is described in detail in Appendix B. A subset of these adjuvants was identified for further examination based upon use patterns and toxicity (Appendix B) and is discussed below.

Table 6-4 Adjuvants Employed for Weed Abatement

Active Ingredient	Appendix B
APEs	Section 4.7.1
Modified Plant Oil and Methylated Seed Oil	Section 4.7.3

Lecithin (phosphatidylcholine)	Section 4.7.4
Aliphatic Polycarboxylate	Not included

Alkylphenol ethoxylates (APEs) include a broad range of chemicals that tend to bind strongly to particulates and persist in sediments. Nonylphenol and short-chain nonylphenol ethoxylates are considered to be moderately bioaccumulative and extremely toxic to aquatic organisms at high exposures. In reality, these chemicals are highly diluted, as they are typically added to an herbicide using only a few ounces in 100 gallons (Gossamer Threads Inc., 1998). At these low dilution concentrations, combined with the limited areas of application, the exposure to nontarget biota is not sufficient to result in adverse effects. Aside from use in agricultural herbicide mixtures, APEs are commonly present in detergents, cleaners, food packaging, and cosmetics. The acute toxicity of APEs to mammals is low. Some think they may be possible estrogen-mimics. Although these chemicals have been used in numerous common products (generally regulated by the Food and Drug Administration), the USEPA has recently recommended that this suite of chemicals be evaluated further due to their widespread use (past and present). Current information about APEs is based on Food and Drug Administration evaluations, but regardless, In order to be conservatively cautious, USEPA has speculated that they may pose a risk to nontarget terrestrial organisms (USEPA 2010).

Plant-derived oils are of two types: triglycerides or methylated oils. Triglycerides are essentially oil-surfactant hybrids and are generally called seed oils. Modified plant oils and methylated seed oils are essentially nontoxic to most organisms, including plants. Little is known of the environmental fate of these adjuvants. Although toxicity and environmental fate information is scarce for these oils, using BMP application practices including appropriate weather parameters to minimize draft, these products should not result in unwanted adverse effects.

Little is known about the toxicity or environmental fate of lecithins. Lecithins are naturally occurring phospholipids in biological cell membranes (Bakke 2007). Although toxicity and environmental fate information for these products is scarce, using BMP application practices including application at the lowest effective concentration for a specific set of vectors and environmental conditions, use of lecithins should not result in unwanted adverse effects to nontarget terrestrial organisms.

Aliphatic polycarboxlyates are another category of adjuvants that are essentially nontoxic to biota and are used as an additive to enhance the efficacy of several other products. They are listed as having no known toxicity or adverse biological impacts as a polymer additive with no hazard indications in any of the typical categories used to define toxicity by regulators. (Kegley et al. 2014)

BMPs the District employs include using adjuvants in limited amounts in areas that do not contain special-status species, coordination with CDFW, USFWS, and/or NMFS before conducting management activities in sensitive habitat, keeping spray nozzles within a predetermined maximum distance of target insect (or weeds), and preventing exposures to nontarget habitats (post-application).

> **Impact ECO-6:** The use of adjuvants would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.

6.2.6 Biological Control Alternative

The Biological Control Alternative would be a continuation of existing activities focused on mosquitofish using applicable techniques, equipment, and vehicles.

Biological control of mosquitoes and other vectors involves the intentional use of vector pathogens (diseases), parasites, and/or predators to reduce the population size of target vectors. Biological control is employed as a method to protect the public from mosquitoes and associated diseases using mosquito parasites, pathogens, and predators. Mosquito parasites are not currently available in the commercial market. Some of the pesticides used on mosquito larvae are bacteria and a form of biological control. These products are not considered chemical treatment; however, they are registered and regulated by

USEPA and are, therefore, covered thoroughly in Section 6.2.7, Chemical Control Alternative. A discussion of mosquitofish as a biological control action and potential impacts to aquatic resources is discussed in Chapter 4.

6.2.6.1 Mosquito Larvae Pathogens

Mosquito pathogens are highly host-specific bacteria or viruses that are ingested during filter-feeding behavior of mosquito larvae in aquatic environments. These pathogens multiply rapidly in the host, destroying internal organs and consuming nutrients. The pathogen can be spread to other mosquito larvae in some cases when larval tissue disintegrates and the pathogens are released into the water and subsequently ingested by other mosquito larvae. The District uses two types of pathogenic bacteria, including Bs, strains of Bti, and may use *Saacharopolyspora spinosa* in the future. Bs and Bti produce proteins that are toxic to most mosquito larvae, while the fermentation of *S. spinosa* produces spinosysns, which are highly effective mosquito neurotoxicants. Bs can reproduce in natural settings for some time following release. Bti materials do not contain live organisms, but only spores made up of specific protein molecules.

All three bacteria are naturally occurring soil organisms, which are commercially produced as mosquito larvicides. Because these forms of biological control are applied in a similar manner to chemical pesticides, they are evaluated under Section 6.2.7, Chemical Control Alternative, including the discussion of potential impacts. The environmental fate and toxicity of these control agents are described in detail in Appendix B.

6.2.6.2 Mosquito Predators

Mosquitofish (*Gambusia affinis*) are presently the only commercially available mosquito predators. The District's rearing and stocking of these fish in mosquito habitats is the most commonly used biological control agent for mosquitoes in the world. Used correctly, this fish can provide safe, effective, and persistent suppression in various mosquito sources. However, due to concerns that mosquitofish may potentially impact red-legged frog and tiger salamander populations, the District limits the use of mosquitofish to artificial habitats including ornamental fish ponds, water troughs, water gardens, fountains, unmaintained swimming pools, and other types of isolated man-made ponds that are not connected to natural waterways. Limiting the introduction of the mosquitofish to these sources is sufficient to avoid impacts to sensitive species in natural habitats.

> **Impact ECO-7:** The use of mosquitofish as a Biological Control Alternative would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.

6.2.7 Chemical Control Alternative

The Chemical Control Alternative would be a continuation of existing activities using applicable techniques, equipment, vehicles, watercraft, and aircraft.

Chemical control is a Program tool that consists of the application of nonpersistent insecticide products demonstrated to reduce populations of larval or adult mosquitoes and other invertebrates (e.g., yellow jacket wasps, ticks). If and when inspections reveal that mosquitoes or other vector populations are present at levels that trigger the District's guidelines for chemical control – based on the vector's abundance, density, species composition, proximity to human settlements, water temperature, presence of predators and other factors – staff will apply pesticides to the site in strict accordance with the pesticide label instructions and the BMPs listed in Section 6.2.2.1. The threshold guidelines for these response triggers are based on previous documentation and monitoring/current surveillance of likely vector outbreaks or expansions of mosquito populations. Additional response triggers are based on verified mosquito populations, outbreaks, discomfort and irritation issues for humans and animals, and public concern about vectors.

The chemicals the District uses for vector control are presented in Tables 6-1 and 6-2 in Section 6.1.2. These pesticides are approved for commercial use by the USEPA and CDPR and, when applied with strict adherence to product label requirements, should not result in adverse effects to nontarget organisms. Detailed discussions of the environmental fate and toxicity of these active ingredients are provided in Appendix B. A subset of these chemicals was selected for further examination based upon potential issues regarding appropriate use patterns, documented environmental fate, or toxicity characteristics of the primary active ingredients (Table 6-5, excluding herbicides discussed previously in Section 6.2.5). These chemicals are discussed in the following section specifically in reference to potential ecological health impacts associated with their use for vector control.

Table 6-5 Chemicals Identified for Further Evaluation in Appendix B

Active Ingredient	Vector	Potential Issue
Methoprene	Mosquitoes	Prevalent use; toxicity to aquatic insects
Etofenprox	Mosquitoes, yellow jacket wasps	Toxicity to aquatic organisms; no synergist required
Bti	Mosquitoes	Prevalent use; public concerns
Pyrethrins	Mosquitoes	Prevalent use; requires synergist (PBO)
Resmethrin	Mosquitoes	Requires synergist (e.g., PBO); potential endocrine disruptor
Aliphatic solvents Plant-derived oil/mineral oil/mix	Mosquitoes	Contains low percentage of petroleum distillate
Permethrin	Mosquitoes	Toxicity to aquatic organisms; potential endocrine disruptor

A few of these pesticides used by the District have the potential to bioaccumulate to varying degrees. Pesticides in use identified as having the potential to bioaccumulate under some conditions are listed below in Table 6-6.

Table 6-6 Pesticides with Potential to Bioaccumulate

Active Ingredient	Vector	Potential to Bioaccumulate
Methoprene	Mosquito (larvae)	Yes
Spinosad	Mosquito (larvae)	Yes
Esfenvalerate	Yellow jacket wasp, tick	Yes
Etofenprox	Mosquito(adults) / yellow jacket wasp	Yes

Although these active ingredients have the potential to bioaccumulate, the conditions in which they are used include the use of ULV application methods for adult mosquito control and highly localized applications for yellow jackets and ticks. The larvicides methoprene and spinosad have been designated as bioaccumulators, but the environmental conditions on the ground and in water after an application of one of these pesticides by the District generally does not provide the continuous exposure needed for substantial bioaccumulation in a nontarget organism with no subsequent biomagnification. Therefore, the impact is less than significant.

6.2.7.1 Mosquito Larvicides

Larvicides are used to manage immature life stages of mosquitoes including larvae and pupae in aquatic habitats. For example, larvicide application(s) can be necessary in temporary aquatic habitats that do not have adequate populations of predators (e.g., fish) or habitats with dense and/or abundant populations of emergent or floating vegetation that can support mosquito production. The larvicides are applied using ground application equipment, watercraft, fixed-wing aircraft, and rotary aircraft. District criteria for selecting larvicide application methods are predicated upon access, efficiency and effectiveness of application, size of the area to be treated, and the density and type of vegetation present at the application site (i.e., the likelihood of success in applying the material to the target area). All of the potential treatment options are considered and weighed to select the most appropriate options prior to use, and physical control and chemical treatment may both be used in the target area. District staff may choose to treat soil and/or surface water in the vicinity of an onsite wastewater treatment system that appears to have failed or malfunctioned due to improper lid seals, cracks, or missing vent screens and/or due to drain fields where water ponds on the surface. In this situation, the District may provide selected mosquito larvicide treatment to the tank and/or the septic leach/drain field and system environs. The larvicides currently used include materials not known to adversely impact septic system bacteria: *Bacillus sphaericus* as an active ingredient (e.g., VectoLex), methoprene (e.g., Altosid briquets), larvicide oils (e.g., BVA 2 and CocoBear), and monomolecular films (e.g., Agnique MMF).

The mosquito larvicides the District uses include bacterial larvicides, hydrocarbon esters, and surfactants (Table 6-7). The toxicity of Bs, Bti, spinosad, methoprene, and monomolecular films are discussed in detail in Appendix B. The District employs practices that alleviate the potential for exposure and adverse effects to nontarget organisms (see Chapter 4 for an inventory of special-status species inhabiting the Program Area).

Table 6-7 Chemicals Employed for Larval Mosquito Abatement

Chemical Classification	Active Ingredient	Appendix B
Bacterial larvicide	Bs	Section 4.3.1
Bacterial larvicide	Bti	Section 4.3.2
Bacterial larvicide	Spinosad	Section 4.3.3
Hydrocarbon ester	Methoprene	Section 4.3.4
Surfactant	Alcohol Ethoxylated Surfactant (monomolecular film)	Section 4.3.5
Surfactant	Aliphatic Hydrocarbons (mineral oil)	Section 4.3.6
Surfactant	Plant-Derived Oils	Section 4.7.3

6.2.7.1.1 Bacterial Larvicides (Bs, Bti, and Spinosad)

Bacterial larvicides such as Bs and Bti are highly effective microbial pesticides (for mosquitoes) that, when ingested, produce gut toxins that cause destruction of the insect gut wall leading to paralysis and death. These microbial agents are delivered as endospores in granular, powder, or liquid concentrate formulations. The District applies Bs and Bti directly to mosquito habitats (marshes, wetlands, ditches, channels, standing water, ponds, waterways, sewers, and storm drains rather than to terrestrial environments. Bs and Bti are practically nontoxic to terrestrial organisms, including birds, bees, and mammals. Microbial larvicides are one of the most environmentally compatible forms of natural pesticides available for commercial use. Bti is a naturally occurring toxicant of mosquito larvae and, therefore, does not pose risk to nontarget ecological receptors.

Spinosad is a natural insecticide derived from the fermentation of a common soil micro-organism, *Saacharopolyspora spinosa*. Spinosad alters nicotine acetylcholine receptors in insects causing constant involuntary nervous system impacts, ultimately leading to paralysis and death. It is of low acute toxicity to birds, but is very highly toxic to moths and butterflies.

The District strictly adheres to product label requirements and BMPs for the protection of ecological health. In particular, only pesticides approved for aquatic areas or manual treatments within a predetermined distance from aquatic features are employed (BMP H10). Pesticides that could affect insect pollinators are not applied over large areas (more than 0.25 acre) during the day when honeybees are present and active (BMP H12).

> **Impact ECO-8:** The use of bacterial larvicides would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.

6.2.7.1.2 Hydrocarbon Esters (Methoprene)

The District widely uses methoprene, an insect growth regulator that is a demonstrated and targeted larvicide when applied at rates labeled for mosquito control. Only when used at rates considerably higher than rates used by the District for mosquito control, can methoprene exhibit some toxicity to some nontarget aquatic invertebrates and some insects such as moths, butterflies, and beetles. Methoprene has also been reported to be moderately toxic to fish; but at the concentrations used for mosquito larvae control, District applications are unlikely to affect nontarget aquatic species.

Although methoprene can exhibit some toxicity to aquatic organisms and insects, it is effective at much lower concentrations than alternative larvicide products. Lower concentrations can translate to reduced acute exposures to nontarget organisms, as well as potential effects to a limited number of midges and chironomids. Extended release forms including granular and briquette varieties are also available (e.g., 30-day briquettes), which are longer lasting and require fewer applications. This product may be more residual in the environment; however, the methoprene active ingredient in this formulation has a short half-life in water and does not migrate through soil, significantly reducing the potential for groundwater impacts.

The District uses methoprene prevalently during each season of the year. Liquid and granular forms are used in residential and ornamental pond application scenarios. Treatments to wetlands including marshes, at times require the granular form (e.g., Altosid pellets) to penetrate dense aquatic vegetation including cattails and tules. See Section 9.2.7.1 for discussion of use of methoprene in malfunctioning onsite wastewater treatment systems.

In some instances, it is necessary to use combinations of products to achieve a more effective vector control that knocks down all larval stages simultaneously. Thus, methoprene is sometimes co-applied with Bti (i.e., Duplex) to maximize the impact to the larval stages and to prevent resistance that might result when only Bti is used for control. Also, larvicide oil and methoprene (e.g., methoprene briquets) may be used together to knock down pupae and achieve residual larval control.

The larger droplet sizes of aerial (e.g., helicopter) larvicide applications (e.g., methoprene) can reduce the potential for unwanted drift (compared to that of ULV applications). In addition, aerial treatments are restricted to times when wind is non-existent or at acceptable levels. Methoprene is generally applied in extremely small amounts during larval treatments due to its efficacy against mosquitoes, even at low concentrations. For example, the District applies it at a maximum concentration of 4.8 µg/L, which is then further diluted in the waterbody to which it is applied. At this application rate, little to no toxicity occurs to nontarget aquatic organisms with the possible exception of some midges (*Chironomidae*) and blackflies (*Simuliidaes*) (Chapter 4; Appendix B). Methoprene has a low toxicity to fish, as evidenced by the lowest 50 percent lethal concentration ($LC_{50,}$ of 4.62 mg/L for bluegill) is several orders of magnitude higher than the concentrations used to control mosquitoes (e.g., 1,000 times concentration, even prior to dilution that occurs in the waterbody) (Maffei, pers. comm., 2013). When handled and applied using District BMPs, methoprene is one of the most environmentally compatible larvicides available.

Impact ECO-9: The use of methoprene for mosquito larvae would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.

6.2.7.1.3 Surfactants

Alcohol ethoxylated surfactants (monomolecular films) and aliphatic solvents (mineral oil) are low-toxicity pesticides that spread a thin film on the surface of water that makes it difficult for mosquito larvae, pupae, and emerging adults to attach to the water's surface, causing them to drown (USEPA 2007). The films also disrupt larval respiration of some other classes of air-breathing aquatic insects. They are used on an assortment of waterbodies including ornamental ponds, pastures, irrigation systems, drainage systems, and drinking water systems (CDPR 2010). Monomolecular films are not environmentally persistent and may typically degrade within 21 days.

Surfactants could result in temporary reductions to populations of surface-breathing insects (other than mosquitoes) during treatment; however, it is unlikely that these reductions would result in lasting or observable effects on nontarget organisms when applied within product label limits (Peterson et. al., 2006). In addition, populations recover quickly following recolonization from adjacent and neighboring sites and habitats (Lawler and Lanzaro 2005).

Aliphatic solvents such as mineral oil are applied to water surfaces to form a coating on top of water surfaces to drown larvae, pupae, and emerging adult mosquitoes. They are the product of petroleum distillation and, thus, are complex mixtures of long-chain aliphatic compounds. They are applied to a variety of waterbodies, including swamps, marshes, and intermittently flooded areas (CDPR 2010a). Aliphatic solvents are often used when monomolecular films (alcohol ethoxylated surfactants) do not provide sufficient mosquito control. They also break down more rapidly (2 to 3 days) and are practically nontoxic to most nontarget organisms. Therefore, mineral oil should not result in adverse ecological effects when applied using District BMPs. These BMPs include coordination with CDFW, USFWS, and/or NMFS before conducting treatment activities in suitable habitat for special-status species including vernal pools (BMP H10). Applications will be postponed or cease when predetermined weather parameters exceed product label specifications (BMP H6).

Plant oil mixes include the use of a small amount of a mineral oil alcohol ethoxylated surfactant and a blend of methyl esters of fatty acids.

Plant-derived oils, whether vegetable or fruit, can be used as adjuvants that enhance the effectiveness of herbicides or as surfactants for the management of vectors, especially immature mosquitoes. Plant-derived oils are generally of two types: triglycerides or methylated oils. CocoBear Mosquito Larvicide Oil is the only plant-based oil that is currently available for use in the District's Program (also see Section 4.3.6.4 in Appendix B). This product consists mostly of a modified coconut oil (75 percent or more by volume) combined with 10 percent by volume mineral oil and a very small amount of nonionic surfactant and other proprietary ingredients. This material can be used in various waterbodies such as ditches, stagnant pools, swamps, marshes, temporary rainwater pools and intermittently flooded areas, ponds, catch basins, and man-made containers for the management of immature mosquitoes. CoCoBear oil has no reported significant toxicity to any receptors likely to be exposed during or after use as a larvicide. Acute oral toxicity to rats is >5,000 milligrams per kilogram (mg/kg), acute dermal toxicity to rats is >5,050 mg/kg, and acute inhalation toxicity to rats is >2.16 mg/L (Clarke 2014).

Impact ECO-10: The use of surfactants for the control of mosquito larvae would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.

6.2.7.2 Mosquito Adulticides

In addition to chemical control of mosquito larvae, the District may use pesticides for control of adult mosquitoes as a component of the IVMP for example, when other tools are not effective or appropriate and adult mosquito control guidelines are met, including species composition, abundance (as measured by landing count or other quantitative method), proximity to human populations, and/or human disease risk. Adulticide materials are used as needed to control adult mosquito populations.

Adulticides the District potentially uses include pyrethrins, synthetic pyrethroids, pyrethroid-like compounds, and synergists. Table 6-8 lists the adulticides the District uses for mosquito abatement. Several of these active ingredients are also used for the control of yellow jacket wasps (Table 6-8 and this section and Section 6.2.7.3). A subset of these active ingredients required further evaluation in Appendix B and further discussion is provided below. A detailed discussion of the environmental fate and toxicity of these pesticides is provided in Appendix B.

Table 6-8 Chemicals Employed for Adult Vector/Insect Abatement

Chemical Classification	Active Ingredient	Vector	Appendix B
Pyrethrin	Pyrethrins	Mosquito, yellow jacket wasp	Section 4.1.1
Pyrethroid	Allethrins and d-*trans* allethrin	Yellow jacket wasp, tick	Section 4.1.2
Pyrethroid	Phenothrin (sumithrin or d-phenothrin)	Mosquito, yellow jacket wasp	Section 4.1.3
Pyrethroid	Prallethrin	Mosquito	Section 4.1.4
Pyrethroid	Deltamethrin	Yellow jacket wasp, tick	Section 4.1.5
Pyrethroid	Esfenvalerate	Yellow jacket wasp, tick	Section 4.1.6
Pyrethroid	Resmethrin	Mosquito	Section 4.1.8
Pyrethroid	Tetramethrin	Yellow jacket wasp	Section 4.1.9
Pyrethroid	Permethrin	Mosquito	Section 4.1.10
Pyrethroid-like compound	Etofenprox	Mosquito, yellow jacket wasp	Section 4.1.11
Synergist	PBO	Mosquito, yellow jacket wasp	Section 4.1.12

6.2.7.2.1 Pyrethrins

Pyrethrins are naturally occurring products distilled from the flowers of certain Chrysanthemum species. Pyrethrins readily degrade in water and soil, but may persist under anoxic conditions. They tend to strongly adsorb to soil surfaces and, hence, have low potential to leach into groundwater. Pyrethrins may be highly toxic to fish (freshwater, estuarine, marine) and invertebrates, although exposures would likely be low during and following ULV applications, which are designed to prevent environmental persistence and potential impacts to nontarget ecological receptors.

The District uses pyrethrin for mosquito and/or yellow jacket wasp control. For yellow jacket wasp control, pyrethrin is applied around parks, landscaping, and directly into ground nests. For mosquito control, pyrethrin is applied to man-made and natural sites but not directly to water.

Pyrethrins are of concern because they are used prevalently and often include the use of the synergist PBO, for greater efficacy, which can then be toxic to aquatic invertebrates. For this reason, and because some

suggest that it may be an endocrine disrupter, it is currently under further evaluation by USEPA. (Section 6.2.7.2.2). However, the District uses pyrethrins only when absolutely necessary and, even then, minimal amounts are applied (ULV application), thus reducing the potential for impacts to nontarget ecological receptors (BMPs H3, H4, H11). As an additional measure, pyrethrin applications are canceled during less than ideal wind and potential drift conditions (BMP H6). For wasp (yellow jacket and paper wasps) control, the District applies pyrethrins in minute volumes directly to ground nests and tree nests if necessary, which essentially negates any impact to nontarget species. The District ensures that all applications are made in accordance with label specifications and USEPA and CDPR recommendations for use with mosquitoes. Other practices that can alleviate risk to aquatic receptors include minimizing the amount, frequency, and area with which these pesticides are applied over waterbodies, especially those with the potential to contain special-status species. The District also minimizes the amount, frequency, and area with which these pesticides are applied over waters draining directly to the waters above. In addition, the risks to nontarget insects such as honeybees are reduced by restricting pyrethrin applications to nighttime, pre-dawn, and dusk hours when bees and other pollinators are inactive (BMP H12). In actual field applications, the hazard to bees is often lessened because bees are repelled by pyrethrins, which can reduce their contact with plant surfaces that have recently been sprayed. Reduced contact with plant surfaces decreases the chance of bees receiving a toxic dose. Also, note that pyrethrins are available in aerosol can form to the public but not in vessels used for ULV applications.

> **Impact ECO-11:** The use of pyrethrins for adult mosquitoes and yellow jacket wasps would result in a **less-than-significant** impact to nontarget ecological receptors including aquatic organisms and bees and mitigation is not required.

6.2.7.2.2 Pyrethroids and Pyrethroid-like Compounds

Pyrethroids are synthetic compounds that are chemically similar to the pyrethrins but have been modified to increase stability and activity against insects. Pyrethroids bind to neuronal voltage-gated sodium channels, preventing them from closing; this persistent activation of the channels then leads to paralysis.

First generation or “Type I” pyrethroids include d-allethrin, phenothrin (sumithrin), prallethrin, resmethrin, and tetramethrin. These pyrethroids are used to control flying and crawling insects in a number of commercial and horticultural applications and are sold for residential use and application on pets to control fleas and ticks. They have effective insect knock-down capabilities but are unstable in sunlight (highly photosensitive). The newer second-generation/”Type II” pyrethroids contain an α-cyano group, which reduces their photosensitivity, thereby increasing their persistence and toxicity. The active ingredients that fall into this group include deltamethrin, esfenvalerate, and permethrin.

Some synthetic insecticides are similar to pyrethroids, such as etofenprox, but have a slightly different chemical composition. The pyrethroids that were identified for further evaluation in Appendix B are discussed below.

Resmethrin

Resmethrin is a pyrethroid (a synthetic class of compounds modified from pyrethrins to increase stability and insecticidal specificity) and the active ingredient in Scourge®. It is a restricted-use pesticide due to its toxicity to fish and is available for this use only by certified pesticide applicators or persons under their direct supervision.

Resmethrin may also be persistent in environments free of light (e.g., bound to organic matter in anoxic soils and sediments). Due to the potential for persistence and high toxicity to both aquatic and estuarine/marine fish and invertebrates, use with PBO, as well as the potential for endocrine disruption, resmethrin may be of concern from an ecological health perspective.

The District infrequently applies resmethrin only when necessary to sites that can include residential areas near reclaimed marshes, wetlands, sewage treatment facilities, and industrial areas for mosquito control. Studies have shown rapid dissipation/low persistence and no observed aquatic fish and invertebrate toxicity following aerial ULV applications. Scourge® may be phased out with a nonresmethrin alternative, making this product less problematic. The District uses resmethrin only when absolutely necessary and then in ULV applications so that the rapid degradation of the products reduces the potential for impacts to nontarget ecological receptors.

Permethrin

Permethrin is a pyrethroid that may persist in environments free of light (e.g., bound to organic matter in anoxic soils and sediments). Due the potential for persistence and high toxicity to both aquatic and estuarine/marine fish and invertebrates, use with PBO, as well as the potential for endocrine disruption, permethrin may be of concern from an ecological health perspective. Although potentially toxic effects would occur to some aquatic species, risk assessments provided in support of registration indicate that the acute and chronic risk quotients for terrestrial avian species are below the USEPA's levels of concern. The acute risk quotients for terrestrial mammals are also below the USEPA's acute levels of concern. (USEPA 2009b).

The District may use permethrin for mosquito control (e.g., marshes, wetlands) and uses permethrin for yellow jacket wasp (residential areas, parks) control during spring, summer, and fall. Permethrin products are used in areas adjacent to areas including reclaimed marshes, sewage treatment plants, wetlands, around residences, and directly to ground nests of yellow jacket wasps.

Studies have shown rapid dissipation/low persistence and no observed aquatic fish and invertebrate toxicity following aerial ULV applications. Based on its potential for endocrine disruption and usage patterns, this product is generally used with careful and strict BMP techniques such as in very small, localized applications. Permethrin use is restricted to situations when it is absolutely necessary and in ULV applications that are designed to degrade rapidly and, thus, reduce the potential for impacts to nontarget ecological receptors.

Etofenprox

Etofenprox is a pyrethroid-like insecticide that is the active ingredient in Zenivex®. It is frequently applied to backyards and patios and sometimes directly to domestic pets. Etofenprox does not tend to persist in the environment or appear to pose a risk to mammals. It does exhibit some toxicity to fish and aquatic invertebrates; however, it degrades rapidly in surface waters, thereby reducing the potential for long-term exposures and adverse effects. Zenivex® does not require synergists such as PBO; therefore, it likely exhibits less toxicity than others that require co-application. In addition, the District strictly adheres to application BMPs, such as monitoring weather conditions during applications (BMPs H6, H7), and product label requirements. Etofenprox is generally applied during the nighttime hours, pre-dawn and at dusk when sensitive receptors such as honeybees are not active (BMP H12).

> **Impact ECO-12:** The use of pyrethroids and pyrethroid-like compounds (e.g., resmethrin, permethrin, and etofenprox) for mosquitoes and yellow jacket wasps would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.

6.2.7.2.3 Synergists (Piperonyl Butoxide)

PBO is a pesticide synergist that enhances the effectiveness of pesticide active ingredients, such as pyrethrins and pyrethroids, by inhibiting microsomal enzymes and, thus, the breakdown of the other active ingredient(s) (USEPA 2006a). It is a registered active ingredient in products used to control flying and crawling insects and arthropods in agricultural, residential, commercial, industrial, and public health settings. No products contain only PBO. It degrades quickly in soil and water but exhibits toxicity to fish and aquatic invertebrates. As a synergist, PBO is applied using the same guidelines as those for

pyrethroids and pyrethrins as indicated by the District: ULV application (to prevent environmental persistence and adverse ecological effects) with a backpack mister or ATV-mounted or handheld ULV, and it is applied as directed on product labels relative to wind conditions.

> **Impact ECO-13:** The use of synergists (PBO) for mosquitoes and yellow jacket wasps would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.

6.2.7.3 Yellow Jacket Wasp and Tick Adulticides

The District also selectively applies chemicals to control ground-nesting yellow jacket wasps, as well as wasps that nest in trees. This activity is generally triggered by public requests for District assistance or action rather than as a result of regular surveillance of their populations. Yellow jacket nests that are off the ground would be treated under special circumstances to protect public health and safety of residents. Whenever District technicians learn that a nest is situated inside or on a structure or is above ground, the resident(s) are encouraged to contact a private pest control company that is licensed to perform this work. When a technician encounters a honeybee swarm or unwanted hive, residents are referred to the County Agricultural Commissioner's Office, which maintains a referral list of beekeepers that can safely remove the bees. If District technicians deem it appropriate to treat stinging insects, they will apply the insecticide directly within the nest in accordance with the District's policies to avoid drift of the insecticide or harm to other organisms. Alternatively, tamper-resistant traps or bait stations, selective for the target insect, could be employed in the immediate environment of the vector.

Pyrethrin and pyrethroid-based chemicals are typically used against ground-nesting yellow jackets. The District does not currently perform control work with respect to tick populations but may potentially do a limited amount of control work in the future using synthetic pyrethroid products such as allethrin and deltamethrin. The potential environmental impacts of these materials is minimal due to two factors: (1) their active ingredients consist largely of pyrethrins (a photosensitive natural insecticide manufactured from a Chrysanthemum species), or allethrin, and phenothrin (first generation synthetic pyrethroids with similar photosensitive, nonpersistent characteristics as pyrethrin); and (2) the mode of their application for yellow jacket population control (i.e., directly into the underground nest), which prevents drift and further reduces the potential for inadvertent exposure to these materials. The pesticides the District uses to control yellow jacket wasps are shown in Table 6-8.

> **Impact ECO-14:** The use of pyrethroids and pyrethroid-like compounds for yellow jacket wasps and ticks would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.

6.2.8 Other Nonchemical Control/Trapping Alternative

The trapping of rodents and/or yellow jackets may be conducted in the future when these organisms pose a threat to public health and welfare. For both vector species, District staff may place the tamper-resistant or baited trap(s) primarily at the request of the property owner or manager. The District does not remove rats or yellow jackets that are in or on structures. When these requests are made, residents are referred to the local animal control or to a directory of private pest control companies. The District conducts limited trapping for vectors (e.g., wood rats, deer mice, and other rats), employing mechanisms and baits specific to target animals to reduce the potential impacts to nontarget ecological receptors.

> **Impact ECO-15:** The Other Nonchemical Control/Trapping Alternative would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.

6.2.9 Cumulative Impacts

"Cumulative impacts" are defined as "two or more individual effects which, when considered together, are considerable or compound or increase other environmental impacts (CEQA Guidelines, Section 15355). Cumulative impacts, as they relate to ecological health include past, present, and reasonably foreseeable actions that potentially impact aquatic/terrestrial mammalian and avian wildlife, herptiles, aquatic organisms, nontarget invertebrates and pollinators, and botanical resources. Cumulative impacts can result from individually minor, but collectively significant, projects taking place over a period of time. The cumulative impact analysis is contained in Section 13.4 and focuses on the potential for the use of pesticides for mosquito and vector control to contribute to regional pesticide use, which is of concern for its potential impacts to nontarget ecological receptors. It includes Table 13-1, Historical Pesticide Use within the Marin-Sonoma Mosquito and Vector Control District's Program Area for 2006–2010 and Table 13-2, Pesticide Use within the Marin/Sonoma Mosquito and Vector Control District's Service Area. From Table 13-1, the total pounds of active ingredients by all users in the District's two-county Service Area was approximately 1,989,143 pounds. Table 13-2 reports on pounds of total product in all cases and pounds of active ingredient for some other products actually used by the District. While the two tables are not directly comparable for overall use, the active ingredient in several cases is only about one-tenth of the amount of the total product. Therefore, the District's pesticide use is only a small fraction of total use in Marin and Sonoma counties.

The incremental effects of the District's use of four pesticides with the potential to bioaccumulate in the environment (i.e., including methoprene and spinosad for mosquito larvae; esfenvalerate and etofenprox for adult mosquitoes/yellow jackets/ticks) do not contribute substantially to large-scale bioaccumulation and regional impacts to ecological health. The limited number and use of the adult insect products (esfenvalerate and etofenprox) in relation to the area of application is inconsequential in the context of existing organisms not being subject to continuous exposure. Although spinosad and methoprene have been designated as potential bioaccumulators, the environmental conditions on the ground and in water after an application of one of these pesticides by the District generally does not provide the continuous exposure needed for substantial bioaccumulation in nontarget organisms. The impact of District applications of these pesticides that could contribute to the bioaccumulation of these pesticides in nontarget animals and the environment is short-lived with such a small fraction of their overall normal exposure to outside stress as to be unremarkable. The four pesticides that have the potential to bioaccumulate are used in such low doses, usually with special application restrictions, and in such prescribed areas as to not substantially impact the regional environment and are not cumulatively considerable.

Although large uncertainty and high variation exist in the reported amounts of pesticide use within the District's Program Area counties, they vary according to particular needs, majority of habitat type, and seasonal vector outbreaks. The District uses BMPs in their pesticide applications for mosquito and vector control and is attempting to reduce total pesticide use where possible consistent with IVM practices.

The District's incremental contributions to overall pesticide use within its Program Area are not substantial and too low to trigger a cumulatively considerable impact. While overall use of pesticides throughout the Program Area may be considered cumulatively significant, the District's incremental contributions to this impact are not cumulatively significant given use of BMPs to mitigate potential impacts. Therefore, the **Program's long-term activities including chemical applications would not contribute considerably to nontarget ecological receptor impacts.** The Program alternatives would not result in significant cumulative impacts to the ecological health of the region.

6.2.10 Environmental Impacts Summary

Table 6-9 presents a summary of impacts to ecological health associated with the six alternatives compared to existing conditions.

Table 6-9 Summary of Ecological Health Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Effects on Ecological Health						
Impact ECO-1: The Surveillance Alternative would have a **less-than-significant** impact on nontarget ecological receptors, including native or special-status plants and animals and mitigation is not required.	LS	na	na	na	na	na
Impact ECO-2: The Physical Control Alternative would have a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	LS	na	na	na	na
Impact ECO-3: The employment of a nonherbicide Vegetation Management Alternative in the form of physical removal would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	LS	na	na	na
Impact ECO-4: The use of any of the selected herbicides as a vegetation management technique would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	LS	na	na	na
Impact ECO-5: The use of glyphosate would result in a **less-than-significant impact** to nontarget ecological receptors and mitigation is not required.	na	na	LS	na	na	na
Impact ECO-6: The use of adjuvants would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	LS	na	na	na
Impact ECO-7: The use of mosquitofish as a Biological Control Alternative would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	na	LS	na	na
Impact ECO-8: The use of bacterial larvicides would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	na	na	LS	na
Impact ECO-9: The use of methoprene for mosquito larvae would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	na	na	LS	na

Table 6-9 Summary of Ecological Health Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact ECO-10: The use of surfactants for the control of mosquito larvae would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	na	na	LS	na
Impact ECO-11: The use of pyrethrins for adult mosquitoes and yellow jacket wasps would result in a **less-than-significant** impact to nontarget ecological receptors including aquatic organisms and bees and mitigation is not required.	na	na	na	na	LS	na
Impact ECO-12: The use of pyrethroids and pyrethroid-like compounds (e.g., resmethrin, permethrin, and etofenprox) for mosquitoes and yellow jacket wasps would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	na	na	LS	na
Impact ECO-13: The use of synergists (PBO) for mosquitoes and yellow jacket wasps would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	na	na	LS	na
Impact ECO-14: The use of pyrethroids and pyrethroid-like compounds for yellow jacket wasps and ticks would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	na	na	LS	na
Impact ECO-15: The Other Nonchemical Control/Trapping Alternative would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	na	na	na	LS

LS = Less-than-significant impact

N = No impact

na = Not applicable

SM = Potentially significant but mitigable impact

SU = Significant and unavoidable impact

6.2.11 Mitigation and Monitoring

Although application scenarios are conducted using rigorous, strict BMPs and treatment schedules that avoid periods when the nontarget receptors may be more sensitive to stresses (nesting, breeding, migration, known movements between habitats [small mammals and reptiles]), the District also conducts surveillance and monitoring of results on a routine basis. Receipt of information about vector outbreaks or unwanted population expansion of vectors of concern is dealt with on a case-by-case basis. Pesticide use is conducted according to the verified requirements and guidance in the product labels (mandated by the USEPA) for the nonhazardous use of labeled products and the ultimate protection of both humans and ecological receptors.

Because all impacts to ecological health are less than significant, no mitigation is required.

7 Human Health

Chapter 7 evaluates whether the Program alternatives would cause any potentially significant impacts to human health. Results of the evaluation are provided at the programmatic level. Section 7.1, Environmental Setting, presents an overview of the District's human population and growth estimates and the federal and state regulations that are applicable to the Program. Section 7.2, Environmental Impacts and Mitigation Measures, presents the following:

> Environmental concerns and evaluation criteria

> Discussion of methods and assumptions

> Discussion of potential impacts of the Program alternatives, and mitigation measures, if necessary, for those impacts

> Cumulative impacts summary

> A summary of estimated impacts to human health

Potential ecological health impacts are addressed in Chapter 6.

7.1 Environmental Setting

The Program Area is defined as the Marin/Sonoma Mosquito and Vector Control District (MSMVCD or the District) and surrounding counties including Lake, Mendocino, Napa, and Solano wherein the District could be called in to assist the county with control of unwanted vectors. The following section provides background information on the population in the Program Area, hazards and exposure, and environmental fate and toxicity of pesticides that may be used by the District and an overview of the regulatory setting with respect to chemical treatment using pesticides.

7.1.1 Population Characteristics of the Program Area

The size of the population in the District's two-county Service Area and the larger Program Area (adjacent four counties) are shown in Table 7-1. In 2010, the population of California was estimated at 37.3 million (US Census Bureau 2010b). The population of the six counties in the District's Program Area is approximately 1.44 million, which represents 4 percent of the statewide total (see Table 7-1).

Table 7-1 Population and Growth in the MSMVCD Program Area (1990–2010)

	Population			Population Growth (Compound Annual Average)	
County* / Area	**1990**	**2000**	**2010**	**1990–2000**	**2000–2010**
Lake	50,631	58,538	64,665	1.46%	1.00%
Marin	230,096	247,289	252,409	0.72%	0.21%
Mendocino	80,345	86,407	87,841	0.73%	0.16%
Napa	110,765	124,279	136,484	1.16%	0.94%
Solano	340,421	394,542	413,344	1.49%	0.47%
Sonoma	388,222	458,614	483,878	1.68%	0.54%
Six-County Area	1,200,480	1,369,669	1,438,621	1.33%	0.49%
Statewide Area	**29,760,021**	**33,871,648**	**37,253,956**	**1.30%**	**0.96%**

*Counties in bold represent the District's Service Area.

The California Department of Finance projects steady population growth in the future, with total state population reaching over 44 million by 2030. These projections represent a compound annual average population growth of 0.86 percent.

7.1.2 Hazards, Toxicity, and Exposure in the Environmental Setting

A "hazardous material" is defined in California Health and Safety Code Section 25501 (p): as "any material that, because of its quantity, concentration, or physical or chemical characteristics, poses a significant present or potential hazard to human health and the environment if released into the workplace or the environment. "Hazardous materials" include, but are not limited to, "hazardous substances, hazardous waste, and any material that a handler or the administering agency has a reasonable basis for believing that it would be injurious to the health and safety of persons or harmful to the environment if released into the workplace or the environment." Any liquid, solid, gas, sludge, synthetic product, or commodity that exhibits characteristics of toxicity, ignitability, corrosiveness, or reactivity has the potential to be considered a "hazardous material."

Many chemicals are widely used in agriculture, commercial pest control, residential landscape/garden habitats, land management by public agencies, and vector control operations to control unwanted pests/vectors and vegetation. These chemicals are developed to effectively impact those pest/vector targets with little to no health risk. To assure the relative safety of these chemicals to humans and wildlife, commercially available chemicals are submitted to numerous laboratory tests by the chemical company, the USEPA (which has final oversight and approval), and state and international agencies to identify possible unintended adverse effects to nontarget humans and wildlife.

Risk assessments conducted to estimate potential adverse impacts to humans include special focused parameters to include children, seniors, and numerous possible human receptor categories based on their likely activity and exposure scenarios. Each of the chemical active ingredients included in this document have undergone extensive evaluations addressing each of the categories of likely activity and exposure and the resulting indicators of risk are provided with a typical range of 10^{-4} to 10^{-6} (one in one thousand to one in a million) to illustrate the estimated risks. This process, conducted using the USEPA guidelines, provides the relative risk to each category of activity for typical human populations. The resulting information is used by the District in its determination of chemicals to use for vector control. The typical volumes and vector control applications of the chemicals discussed in this document are far lower than would be of any concern in a human health risk estimate.

To address the potential risks to special populations of humans, risk assessments are conducted by the chemical company scientists and validated by the USEPA to estimate potential adverse impacts to humans, including special parameters to include children, seniors, and numerous possible human recreational activities, and professional applicators. Some groups of people, such as the elderly, people with health conditions, pregnant women, and infants and children, could be more sensitive to a pesticide due to special exposure conditions and life stage. The regulatory agencies in their recommended risk assessment process emphasize addressing the potential impact to sensitive individuals and populations of humans.

Children: Special parameters considered for children are included in the USEPA's risk assessments to consider the potential susceptibility of children due to several special conditions. Children are evaluated as a separate population using child-specific temporal and physical exposure factors, which address the following:

> Children may have greater exposures to some environmental contaminants than adults (for example, through increased consumption per body weight of certain foods that may be contaminated).

> Behavior patterns, such as playing close to the ground and hand-to-mouth activity, also may increase their exposure to contaminants.

> Children may be more vulnerable to environmental hazards because their organ systems are still developing and may be sensitive to certain chemicals.

> Children also may differ from adults in their metabolism, detoxification, and excretion of some chemicals.

Edlerly persons; In comparison to adult residents, the liver and kidneys of the elderly may become less able to remove chemicals so that older adults may have health problems after a pesticide exposure because the chemical may have more time to react. Consequences of chemical exposure to some elderly persons may be exacerbated by depressed immune and disease-fighting systems, although difficult to assess as a direct effect of the chemical. Although some additional concern may exist about exposures of the elderly to pesticides, their sensitivity to chemicals generally follows similar patterns of "adult residents" in the risk process but are provided an additional measure of consideration if these exposures are particularly likely (i.e., gardening, etc.).

For human risks, the primary animal models are rats, mice, and rabbits. Extrapolations to humans then involve several large safety factors that essentially "dilute" the likely exposure levels to assure risk-averse human exposures (i.e., the rat data for an effect are divided by several orders of magnitude for potential human effects). These tests ensure the likely safety of the chemical of interest under the proposed usage scenarios.

7.1.2.1 Toxicity and Exposure

Toxicology is the study of a compound's potential to elicit an adverse effect in an organism. The toxicity of a compound is dependent upon the following:

> exposure, including the specific amount of the compound that reaches an organism's tissues (i.e., the dose),

> duration of time over which a dose is received, the potency of the chemical for eliciting a toxic effect (i.e., the response), and

> the sensitivity of the organism receiving the dose of the chemical.

Toxicity effects are measured in controlled laboratory tests on a dose/response scale, in which the probability of a toxic response generally increases as the dose increases. Exposure to a compound is necessary for potential toxic effects to occur. However, exposure does not, in itself, imply that toxicity will occur in all circumstances. Thus, toxicity and adverse effects can be mitigated by limiting potential exposure to a dose less than the amount that may result in adverse health effects.

The toxicity data included in the tables and charts in this document are generally derived from rigidly controlled laboratory animal studies designed to determine the potential adverse effects of the chemical under several possible routes of exposure. In these studies, the species of interest is exposed to 100 percent chemical at several doses to determine the lowest concentration resulting in a predetermined adverse effect (LOAEL) on numerous selected physiological and behavioral systems. The second component of these tests is to determine the highest concentration of chemical that results in no measurable adverse effect (NOAEL). These two levels are used to describe the potential range of exposures that could result in adverse effects, including the highest dose with no observed effects.

However, these and other coordinated and focused laboratory tests are designed to document the effects of the chemical using a continuous, controlled laboratory exposure that does not realistically reflect the likely patchy exposures typical of the District field application scenarios. As such, the toxicity information generated using laboratory tests (and some limited field tests) are intended as an overview of potential issues that might be associated with maximum direct exposures. This information is used to develop and recommend guidance for use that should provide maximum exposure levels of applications that are protective of ecological health. These guidelines include numerous "safety margins" in the toxicity

calculations that are intended to provide adequate efficacy to target organisms while not adversely impacting humans or nontarget plant and animal species. In some instances, the regulatory guidance may include additional suggestions for protective application to assure no significant adverse effects on nontarget species and humans.

The regulatory community uses this basic information to provide a relative comparison of the potential for a chemical to result in unwanted adverse effects and this information is reflected in the approved usage labels and material safety data sheets (MSDSs),[1] in actual practice, the amounts actually applied by the District within the District's Program Area are often substantially less than the amounts used in the laboratory toxicity studies. Because of these large safety factors used to develop recommended product label application rates, the amount of chemical resulting in demonstrated toxicity in the laboratory is much higher than the low exposure levels associated with an actual application for vector control. The application concentrations consistent with the labels or MSDSs are designed to be protective of the health of humans and other nontarget species (i.e., low enough to not kill them, weaken them, or cause them to fail to reproduce). Although numerous precautions (BMPs) and use of recommended application guidance are intended to provide efficacy without adverse effects to nontarget organisms, misapplication or unexpected weather conditions may still result in effects on some nontarget organisms in the exposure area. This potential impact is ameliorated by careful use of BMPs and advance planning by the District.

Although laboratory toxicity testing focuses on tiered concentrations of chemical exposure, the results of these tests produce a series of toxicity estimates of concentrations less than those that produce mortality. Extrapolation of these data is used to generate estimates of chronic toxicity or possible effects of lower doses that may result in sublethal effects such as reproduction or metabolic changes. In reality, these low-dose exposures need to be sustained over longer periods than are relevant to typical application scenarios for vector control including multiple applications in an area such as a wetland.

7.1.2.2 Chemistry, Fate, and Transport

Various biological, chemical, and physical parameters affect the behavior of a compound in the environment and its potential toxicity. The chemistry, fate, and transport of a compound must be analyzed to fully estimate potential exposure. The fate and transport of a compound is determined by the physical and chemical properties of the compound itself and the environment in which it is released. Thus, the following characteristics of a compound must be evaluated: its half-life in various environmental media (e.g., sediment, water, air); photolytic half-life; lipid and water solubility; adsorption to sediments and plants; and volatilization. Environmental factors that affect fate and transport processes include temperature, rainfall, wind, sunlight, water turbidity, and water and soil pH. Information pertaining to these parameters allows evaluation of how compounds may be transported between environmental media (e.g., from sediments to biota), how a compound may be degraded into various breakdown products, and how long a compound or its breakdown products may persist in different environmental media. In general, when a compound or its breakdown products decomposes rapidly in the environment and does not persist for extended periods, then the compound or product poses a lower risk to nontarget species and a lower potential for environmental impacts. Appendix B, *Ecological and Human Health Assessment Report*, provides a discussion of the environmental fate of the pesticide active ingredients and other chemicals associated with specific pesticide formulations used in the Program alternatives.

[1] Although the MSDS format is referenced in this document, it should be noted that under the international Globally Harmonized System, the MSDS format has been substantially revised and is now largely replaced by standardized Safety Data Sheets (SDSs).

7.1.3 Program Pesticides and the Environment

The pesticide and herbicide active ingredients included in the Proposed Program are listed in Tables 7-2 and Table 7-3, respectively. Appendix B provides the results of review and evaluations of the active ingredients and adjuvants the District currently uses or proposes to use to control vectors and manage vegetation that provides habitat for mosquitoes.

Table 7-2 Pesticide Active Ingredients

Active Ingredient	Vector
Biodegradable Alcohol Ethoxylated Surfactant	Mosquito (larvae and pupae)
Aliphatic Solvents (e.g., mineral oil, aliphatic petroleum hydrocarbons)	Mosquito (larvae and pupae)
Methoprene	Mosquito (larvae)
Bacillus sphaericus (Bs)	Mosquito (larvae)
Bacillus thuringiensis israelensis (Bti)	Mosquito (larvae)
Spinosad	Mosquito (larvae)
Deltamethrin	Yellow jacket wasp, tick
Tetramethrin	Yellow jacket wasp
Permethrin	Mosquito (adults)
Pyrethrins	Mosquito/yellow jacket wasp, tick
Resmethrin	Mosquito (adults)
Phenothrin	Mosquito/yellow jacket wasp
Allethrins and d-*trans*-allethrin	Yellow jacket wasp, tick
Prallethrin	Mosquito (adults)
Esfenvalerate	Yellow jacket wasp, tick
Etofenprox	Mosquito/yellow jacket wasp
Piperonyl Butoxide (PBO)	Mosquito/yellow jacket wasp

Table 7-3 Herbicide Active Ingredients and Adjuvants

Active Ingredient	Vector
Imazapyr	Vegetation
Glyphosate	Vegetation
Triclopyr	Vegetation
Alkylphenol Ethoxylates (APEs)	Vegetation
Modified Plant Oil/Methylated Seed Oil	Vegetation
Lecithin (phosphatidylcholine)	Vegetation
Aliphatic Polycarboxylate	Vegetation

7.1.4 Regulatory Environment

Formulations proposed for each Program alternative for vector control are and would be used according to federal and state regulatory requirements for the registration, transportation, and use of pesticides. The regulatory framework pertaining to the use of pesticides is discussed below.

7.1.4.1 Federal

The USEPA regulates pesticides under two major statutes: the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Federal Food, Drug, and Cosmetic Act (FFDCA). Under these acts, the USEPA mandates extensive scientific research to assess risks to humans, domestic animals, wildlife, plants, groundwater, and beneficial insects before granting registration for a pesticide. These studies allow the USEPA to assess the potential for human and ecological health effects. When new data raise concern about a registered pesticide's safety, the USEPA may take action to suspend or cancel its registration. The USEPA may also perform an extensive special review of a pesticide's risks and benefits and/or work with manufacturers and users to implement changes in a pesticide's approved use (e.g., reducing application rates).

7.1.4.1.1 Federal Insecticide, Fungicide, and Rodenticide Act

FIFRA defines a pesticide as "any substance intended for preventing, destroying, repelling, or mitigating any pest." The act requires USEPA registration of pesticides prior to their distribution for use in the US, sets registration criteria (testing guidelines), and mandates that pesticides perform their intended functions without causing unreasonable adverse effects on people and the environment when used according to USEPA-approved label directions. FIFRA defines an "unreasonable adverse effect on the environment" as "(1) any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of the pesticide, or (2) a human dietary risk from residues that result from a use of a pesticide in or on any food inconsistent with the standard under Section 408 of the Federal Food, Drug, and Cosmetic Act (21 USC 346a)."

FIFRA regulates only the active ingredients of pesticides, not inert ingredients, which manufacturers are not required to reveal. However, toxicity studies conducted under FIFRA are required to evaluate the active ingredient and the entire product formulation, through which any potential additive or synergistic effects of inert ingredients are established.

7.1.4.1.2 Federal Food, Drug, and Cosmetic Act

The FFDCA authorizes the USEPA to set tolerances (i.e., maximum allowable amounts) for pesticide residues in/on food. Thus, the FFDCA does not expressly regulate pesticide use, but exceedance of tolerances may result in prosecution or changes in the approved use of a pesticide regulated under FIFRA.

7.1.4.1.3 Clean Water Act and National Pollutant Discharge Elimination System

The CWA establishes the principal federal statutes for water quality protection "to restore and maintain the chemical, physical, and biological integrity of the nation's water, to achieve a level of water quality which provides for recreation in and on the water, and for the propagation of fish and wildlife."

> Section 303(d) requires each state to provide a list of impaired waters that do not meet or are expected not to meet state water quality standards as defined by that section. The CWA regulates potentially toxic discharges through the NPDES and ambient water quality through numeric and narrative water quality standards. The release of aquatic pesticides into waters of any state may require an NPDES permit, depending on the pesticide considered, and the conditions proposed for application.

> Section 402, the NPDES, requires permits for pollution discharges (except dredge or fill material) into US waters, such that the permitted discharge does not cause a violation of federal and state water quality standards. Biological and residual pesticides discharged into surface waters constitute pollutants and require coverage under an NPDES permit. In California, NPDES permits are issued by the SWRCB or the RWQCBs.

7.1.4.1.4 Safe Drinking Water Act of 1974

Under the Safe Drinking Water Act of 1974, the USEPA establishes Maximum Contaminant Levels (MCLs), which are specific concentrations that cannot be exceeded for a given contaminant in surface water or groundwater. USEPA has the ability to enforce these nationwide standards or delegate administration and enforcement duties to state agencies. The CDPH administers the federal Safe Drinking Water Act in California.

7.1.4.1.5 California Toxics Rule

In 2000, the USEPA developed water quality criteria for priority toxic pollutants to protect human health and the environment when a gap in California's water quality standards was created when the state's water quality control plans containing water quality criteria for priority toxic pollutants were overturned in 1994 (thus causing California to be out of compliance with the CWA). These established criteria are to be applied to inland surface waters, enclosed bays, and estuaries in California. The rule includes aquatic life criteria for 23 priority toxic pollutants, human health criteria for 57-priority toxics, and a compliance schedule.

7.1.4.2 State of California

California's programs for the registration of pesticides and commercial chemicals parallel federal programs, but many of California's requirements are stricter than federal requirements. The Cal/EPA regulates registration of pesticides and commercial chemicals in California. Within Cal/EPA, the CDPR oversees pesticide evaluation and registration through use enforcement, environmental monitoring, residue testing, and reevaluation. The CDPR works with County Agricultural Commissioners, who evaluate, develop conditions of use, approve, or deny permits for restricted-use pesticides; certify private applicators; conduct compliance inspections; and take formal compliance or enforcement actions. The Secretary of Resources has certified California's pesticide regulatory program as meeting CEQA requirements (CDPR 2006).

California also requires commercial growers and pesticide applicators to report commercial pesticide applications to local county agricultural commissioners. The CDPR compiles this information in annual pesticide use reports. The CDPR's Environmental Hazards Assessment Program collects and analyzes environmental pesticide residue data, characterizes drift and other offsite pesticide movement, and evaluates the effect of application methods on movement of pesticides in air. If a pesticide is determined to be a toxic air contaminant, appropriate control measures are developed with the California Air Resources Board to reduce emissions to levels that adequately protect public health. Control measures may include product label amendments, applicator training, restrictions on use patterns or locations, and product cancellations.

7.1.4.2.1 Porter-Cologne Act and State NPDES Permitting

Under the Porter-Cologne Act (California Water Code Section 13000) the SWRCB, and the state's nine RWQCBs that it oversees, are responsible for administering federal and state water quality regulation and permitting duties.

The SWRCB oversees pesticide NPDES permitting in California. Users of selected larvicide and adulticide registered products are required to obtain coverage under the Statewide NPDES Permit for Biological and Residual Pesticide Discharges to Waters of the US from Vector Control Applications (SWRCB Water Quality Order No. 2012-0003-DWQ; NPDES No. CAG 990004; Vector Control Permit).

Users of certain aquatic herbicides are required to obtain coverage under the Statewide General NPDES Permit for the Discharge of Aquatic Pesticides for Aquatic Weed Control in Waters of the US (SWRCB Water Quality Order No. 2004-0009-DWQ; NPDES No. CAG 990005; Aquatic Weed Control Permit). Pesticides that require state NPDES permitting include Bti, Bs, temephos, spinosad, petroleum distillates, naled, pyrethrin, permethrin, resmethrin, prallethrin, PBO, etofenprox. Permits are discussed in detail in Chapter 9, Section 9.1.2.2.9.

7.1.4.2.2 Safe Drinking Water Act 1976

The CDPH administers the federal Safe Drinking Water Act in California. In addition to enforcing the primary MCLs (discussed above in Section 7.1.4.1), CDPH uses as guidelines Secondary MCLs that regulate constituents that affect water quality aesthetics (such as taste, odor, or color).

Additionally, under the California Safe Drinking Water Act, Cal/EPA's Office of Environmental Health Hazard Assessment develops Public Health Goals (PHGs) for contaminants in California's publicly supplied drinking water. PHGs are concentrations of drinking water contaminants that pose no significant health risk if consumed for a lifetime, based on current risk assessment principles, practices, and methods. Public water systems use PHGs to provide information about drinking water contaminants in their annual Consumer Confidence Reports.

7.1.4.2.3 The Safe Drinking Water and Toxic Enforcement Act (Proposition 65)

This act, passed as a ballot initiative in 1986, requires the state to annually publish a list of chemicals known to the state to cause cancer or reproductive toxicity so that the public and workers are informed about exposures to potentially harmful compounds. Cal/EPA's Office of Environmental Health Hazard Assessment administers the act and evaluates additions of new substances to the list. Proposition 65 requires companies to notify the public about chemicals in the products they sell or release into the environment, such as through warning labels on products or signs in affected areas, and prohibits them from knowingly releasing significant amounts of listed chemicals into drinking water sources.

7.1.4.2.4 California Pesticide Regulatory Program

CDPR regulates the sale and use of pesticides in California. CDPR is responsible for reviewing the toxic effects of pesticide formulations and determining whether a pesticide is suitable for use in California through a registration process. Although CDPR cannot require manufacturers to make changes in labels, it can refuse to register products in California unless manufacturers address unmitigated hazards by amending the pesticide label. Consequently, many pesticide labels that are already approved by the USEPA also contain California-specific requirements. Pesticide labels defining the registered applications and uses of a chemical are mandated by USEPA as a condition of registration. The label includes instructions telling users how to make sure the product is applied only to intended target pests, and includes precautions the applicator should take to protect human health and the environment. For example, product labels may contain such measures as restrictions in certain land uses and weather (i.e., wind speed) parameters.

7.2 Environmental Impacts and Mitigation Measures

This section evaluates the potential impacts from the Program alternatives, focusing on the human health impacts specific to the use of selected chemical and biological pesticides.

7.2.1 Evaluation Concerns and Criteria

The public has indicated concerns about some of the following issues. While not required, the responses to the concerns help to direct the reader to the appropriate section or Appendix B, *Ecological and Human Health Assessment Report*, or they provide explanatory information in concise form.

> The PEIR should address Program impacts on people and pets through ingestion and absorption pathways and proposed mitigation. Address impacts on chemically sensitive people and sensitive populations such as children, the elderly, pregnant women. Exposure to pesticides can result in compromised immune system, which would allow for development of allergies or autoimmune disorders.

- Potential Chemical Control Alternative impacts are discussed in Section 7.2.7, and toxicity of individual active ingredients is evaluated in greater detail in Appendix B.
- Risk assessments conducted to estimate potential adverse impacts to humans include special focused parameters to include children, seniors, and numerous possible human receptor categories based on their likely activity and exposure scenarios. Each of the chemical active ingredients included in this document have undergone extensive evaluations addressing each of the categories of likely activity and exposure and the resulting indicators of risk are provided with a typical range of 10^{-4} to 10^{-6} (one in one thousand to one in a million) to illustrate the estimated risks. This process, conducted using the USEPA guidelines provides the relative risk to each category of activity for typical human populations. The resulting information is used by the District in its determination of chemicals to use for vector control. The typical volumes and applications of the chemicals discussed in this document are far lower than would be of any concern in a human health risk estimate. The resulting additional modifications to recommended vector control applications (District BMPs) are designed, and have been shown, to reduce risk to these especially sensitive human populations. See Section 7.1.2 for more information.

> The PEIR must list any and all biological or chemical agents proposed for use.

- The biological and chemical pesticide formulations included in the Program are listed in Table 7-2, Pesticide Active Ingredients and Table 7-3, Herbicide Active Ingredients and Adjuvants.

> CDPH should be consulted to ensure all potential risks are identified, characterized, and evaluated.

- The PEIR document and information will be made publicly available and will be reviewed by the appropriate regulatory bodies.

> Concern expressed over public safety and health with regards to existing vegetable gardens and fruit trees within the project area. Local swimming holes could be a potential habitat for breeding mosquitoes, and chemical treatment could impact humans.

- BMPs to reduce exposure to humans and human use areas are discussed in Chapter 2 (Table 2-6), Section 7.2.7 herein, summarized in several other relevant chapters (e.g., Chapters 4 and 6), and evaluated in greater detail in Appendix B.

> Concerned with use of Zenivex®; it mimics chrysanthemums but is a harmful neurotoxin.

- Etofenprox, the active ingredient in Zenivex®, is discussed in Section 7.2.7.2.2 and evaluated in greater detail in Appendix B. It does not require concomitant use of a synergist, such as PBO. Therefore, it likely exhibits less toxicity than others that require co-application with other chemicals. Based on toxicity, environmental fate, and usage patterns, etofenprox is not likely to result in unwanted adverse impacts to humans when BMPs are used.

> Concerned that adulticides present danger to humans, as many are known carcinogens and endocrine disruptors.
  - The District's BMPs provide that adulticides are generally applied using ULV techniques to minimize exposure to nontarget species. Aerial and ground application techniques are used to distribute the insecticides. The potential toxicity of the various adulticides included in the Program are discussed in Section 7.2.7-and evaluated in greater detail in Appendix B.

> Concerned that pyrethrins disrupt the normal functioning of sex hormones, while PBO affects the functioning of hormone-related organs.
  - The District generally uses pyrethrins in ULV applications, which are designed to prevent environmental persistence and potential impacts to nontarget species.
  - As a synergist for pyrethrins and pyrethroids, PBO is also generally applied in ULV, and it degrades rapidly in soil and water. Its potential toxicity is discussed in Appendix B.

> How long are pesticides retained in humans (young infant through elderly), pets, home garden vegetables and fruit, etc.?
  - The half-lives of the 42 active ingredients and 4 adjuvants/surfactants used by 9 vector control districts/agencies are listed in Appendix B.

> In addition to short-term effects, what are the long-term effects of repeated exposure to these chemicals?
  - The chronic effects of the various pesticides are discussed in detail in Appendix B.

The CEQA Guidelines Appendix G, *Environmental Checklist Form*, does not contain criteria for determining significance of impacts to human health from the use of pesticides and herbicides. The criteria for hazards and hazardous materials (Checklist Section VIII) are primarily addressed in Chapter 8. However, the first criterion is partly applicable and asks would the project:

a. Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?

The applicability is for the use of these chemicals. In short, the determination of significance is based on the potential to adversely affect human health based on existing data and application methods including label requirements and additional BMPs the District employs (see Section 2.9). The specific concern is whether the activities used to control pest species could result in direct or indirect impacts to human populations in a treatment area in the short term (i.e., acute toxicity) or over the long term (i.e., chronic toxicity).

7.2.2 Evaluation Methods and Assumptions

Pesticides the District uses were investigated to provide a preliminary assessment of the potential impacts to humans (discussed in detail in Appendix B). A comprehensive literature review was conducted, and the District supplied information to assess potential exposure and toxicity. Information collected included the following:

> Pesticides the District uses or may use

> Pesticide label requirements

> Types of application sites (e.g., habitat types)

> Application procedures

> Estimated applications and sites

> Estimated total amount used per quarter

> Physicochemical properties of the pesticides/active ingredients

> Efficacy of the pesticide to eradicate the target pest

> Reported adverse effects (e.g., reproductive, developmental, carcinogenic)

Each of the pesticides identified as warranting further evaluation in Appendix B are known to exhibit at least one parameter that appears to exhibit potential or perceived risk. Toxicity levels (e.g., slight, low, moderate, high, etc.) are used prevalently in the published literature but are not uniformly standardized or representative of specific criteria. They qualitatively describe toxicity in relative terms in the evaluations of herbicides and pesticides in this PEIR and in Appendix B. Toxicity levels are helpful in making significance determinations under CEQA.

The pesticide application scenarios that result in reasonable efficacy with minimal unwanted estimated risk are preferred and are the basis of IPM/IVM approaches and BMPs the District employs. All BMPs are described in Chapter 2 (Table 2-6), and the most relevant BMPs for avoidance or minimization of impacts to human health are repeated below. These BMPs are part of the Program description and are important in making significance determinations under CEQA.

For all currently used Program alternatives, the District applies the following BMPs:

> Operation of noise-generating equipment (e.g., chainsaws, wood chippers, brush-cutters, pickup trucks) will abide by the time-of-day restrictions established by the applicable local jurisdiction (i.e., City and/or County) if such noise activities would be audible to receptors (e.g., residential land uses, schools, hospitals, places of worship) located in the applicable local jurisdiction. Shut down all motorized equipment when not in use. (BMP A11)

> For operations that generate noise expected to be of concern to the public, the following measures will be implemented: (BMP A12)

  - *Measure 1.* Provide Advance Notices: A variety of measures are implemented depending on the magnitude/nature of the activities the District undertakes and may include, but are not limited to, press releases, social media, district websites, emails, phone messages, hand-delivered flyers, and posted signs. Public agencies and elected officials also may be notified of the nature and duration of the activities, including the Board of Supervisors or City Council, environmental health and agricultural agencies, emergency service providers, and airports.

  - *Measure 2.* Provide Mechanism to Address Complaints: District staff is available during regular business hours to respond to service calls and address concerns about nighttime operations.

> The District will perform public education and outreach activities. (BMP A13)

> To minimize air and GHG emissions, engine idling times will be minimized either by shutting equipment and vehicles off when not in use or by reducing the maximum idling time to 5 minutes. Clear signage will be provided for workers at all access points. Correct tire inflation will be maintained in accordance with manufacturer's specifications on wheeled equipment and vehicles to prevent excessive rolling resistance. All equipment and vehicles will be maintained and properly tuned in accordance with manufacturer's specifications. All equipment will be checked by a certified visible emissions evaluator if visible emissions are apparent to onsite staff. (BMP A14)

> A hazardous spill plan will be developed, maintained, made available, and staff trained on implementation and notification for petroleum- based or other chemical-based materials prior to commencement of vector treatment activities. (BMP I5)

> Equip all vehicles used in wildland areas with a shovel and/or a fire extinguisher during the fire season. (BMP J1)

> Train employees on the safe use of equipment and machinery, including vehicle operation. (BMP J2)

> District will regularly review and update their existing health and safety plan to maintain compliance with all applicable standards. Employees will be required to review these materials annually. (BMP J3)

For five Program alternatives, only excluding Biological Control, the following BMPs are protective of human health:

> Vehicles driving on levees to travel through tidal marsh or to access sloughs or channels for surveillance or treatment activities will travel at speeds no greater than 10 miles per hour to minimize noise and dust disturbance. (BMP A8)

For the Vegetation Management and Chemical Control Alternatives, the District uses the following BMPs:

> District staff will conduct applications with strict adherence to product label directions that include approved application rates and methods, storage, transportation, mixing, and container disposal. (BMP H1)

> Materials will be applied at the lowest effective concentration for a specific set of vectors and environmental conditions. Application rates will never exceed the maximum label application rate. (BMP H3)

> To minimize application of pesticides, application of pesticides will be informed by surveillance and monitoring of vector populations. (BMP J4)

> District staff will follow label requirements for storage, loading, and mixing of pesticides and herbicides. Handle all mixing and transferring of herbicides within a contained area. (BMP J5)

> Postpone or cease application when predetermined weather parameters exceed product label specifications, when wind speeds exceed the velocity as stated on the product label, or when a high chance of rain is predicted and rain is determining factor on the label of the material to be applied. (BMP H6)

> Applicators will remain aware of wind conditions prior to and during application events to minimize any possible unwanted drift to waterbodies, and other areas adjacent to the application areas. (BMP H7)

> Spray nozzles will be adjusted to produce larger droplet size rather than smaller droplet size. Use low nozzle pressures where possible (e.g., 30 to 70 pounds per square inch). Keep spray nozzles within a predetermined maximum distance of target weeds (e.g., within 24 inches of vegetation for hand application) or vectors. Adjusting droplet size would only apply to larvicides, herbicides, and non-ULV applications. Use ULV applications that are calibrated to be effective and environmentally compatible at the proper droplet size (about 10 to 30 microns). (BMP H8)

> Clean containers at an approved site and dispose of at a legal dumpsite or recycle in accordance with manufacturer's instructions if available. (BMP H9)

> District staff will monitor sites post-treatment to determine if the target vector or weeds were effectively controlled with minimum effect to the environment and nontarget organisms. This information will be used to help design future treatment methods in the same season or future years to respond to changes in site conditions. (BMP H11)

> The District will provide notification to the public (24 to 48 hours in advance, if possible) and/or appropriate agency(ies) when applying pesticides or herbicides for large-scale treatments that will occur in close proximity to homes, heavily populated, high traffic, and sensitive areas. The District infrequently applies or participates in the application of herbicides in areas other than District facilities. (BMP H13)

> Exercise adequate caution to prevent spillage of pesticides during storage, transportation, mixing, or application of pesticides. Report all pesticide spills and cleanups (excepting cases where dry materials may be returned to the container or application equipment). (BMP I1)

> Maintain a pesticide spill cleanup kit and proper protective equipment at the District's Service Yard and in each District truck used for pesticide transport. (BMP I2)

> Manage spill sites to prevent entry by unauthorized personnel. Contain and control the spill by stopping it from leaking or spreading to surrounding areas, cover dry spills with polyethylene or plastic tarpaulin, and absorb liquid spills with appropriate absorbent materials. (BMP I3)

> Properly secure the spilled material, label the bags with service container labels identifying the pesticide, and deliver them to a District Supervisor for disposal. (BMP I4)

> Field-based mixing and loading operations will occur in such a manner as to minimize the risk of accidental spill or release of pesticides. (BMP I6)

This evaluation assumes that all pesticides are applied in accordance with label instructions and USEPA and CDPR requirements (and in consideration of the local context for that area, i.e., nearby area land uses and habitats). The USEPA requires mandatory statements to be included on pesticide product labels that include directions for use; precautions for avoiding certain dangerous actions; and where, when, and how the pesticide should be applied. This guidance is designed to ensure proper use of the pesticide and prevent unreasonable adverse effects to humans and the environment. All pesticide labels are required to include the name and percentage by weight of each active ingredient in the product/formulation. Toxicity categories for product hazards and appropriate first-aid measures must be properly and prominently displayed. Pesticide labels also outline proper use, storage, and disposal procedures, as well as precautions to protect applicators. The directions for use indicate listing of target organisms, appropriate application sites, application rates or dosages, contact times, and required application equipment for the pesticide. Warnings regarding appropriate wind speeds, droplet sizes, or habitats to avoid during application are also prominently displayed.

This evaluation does not include assumptions about which alternative treatment strategy(ies) would be applied in any given area. This evaluation assumes that important parameters, such as media half-life, are dependent on the specific conditions at the time of pesticide application, and values listed herein serve as references values.

Concerning the application of multiple chemical treatments in the same area, such as larvicides followed by adulticides (i.e., not likely to occur under normal circumstances), or the application of multiple pesticides at the same time in a specific area (e.g., usually multiple active ingredients in the formulation such as VectoMax which combines Bti and Bs), the following information applies.

> Most products sold as herbicides and pesticides are evaluated herein both for the active ingredient and for the adjuvants and surfactants used to make the product more useful. When multiple products are used in a vector control application, the impacts are weighed against the proximity and timing of each application. If products with a similar or even different active ingredient are applied simultaneously, it is likely that the net effect could be the sum of the effects of active ingredients to the vector. However, for vector control applications materials with the same active ingredient are not applied to the same specific area simultaneously at a given site. The need for reapplication of mosquito larvicides or adulticides is surveillance driven and performed per the label directions. The District can apply larvicide materials with different active ingredients during a single application. This type of application is necessary if multiple hatches of mosquito larvae occur and results in mosquito populations occurring at different stages of the life cycle. An example of this occurs when liquid Bti and methoprene are applied simultaneously. When this occurs, the combination of the material is a product called Duplex, and the mixture of the materials and active ingredients is provided for on the product labels. Another example for the District includes a pre-application of a liquid trans-allethrin and phenothrin spray product may be used to minimize the hazard of approaching a yellow jacket nest. Situations that would produce a residual exposure adequate to cause harm to humans would not occur unless the application(s) were inappropriate or the timing of applications is inappropriately close. Actual applications do not

generally occur that close together unless there is a problem with treatment effectiveness. A material is applied followed by post treatment inspection to determine effectiveness. Only if the mosquitoes/vectors have not been sufficiently killed would the District go back into the area and reapply a pesticide.

7.2.3 Surveillance Alternative

Vector surveillance is critical to IVM strategies because it provides information that is used to determine when and where to institute other vector control measures. The District's mosquito surveillance activities are conducted in compliance with accepted federal and state guidelines (e.g., *California Mosquito-Borne Virus Surveillance & Response Plan* [CDPH et al. 2013] and *Best Management Practices for Mosquito Control in California* [CDPH and MVCAC 2012]), continued in Appendix F. These guidelines allow for flexibility in selection and specific application of control methods because local areas vary.

District practices would be a continuation of existing activities using applicable techniques, equipment, vehicles, and watercraft. Surveillance activities involve monitoring the distribution and abundance of adult and larval mosquitoes, field inspection of mosquito habitat, testing for the presence of encephalitis virus-specific antibodies in sentinel chickens or wild birds, collection and testing of ticks, small rodent trapping, and/or response to public service requests regarding problematic animal or insect vectors (e.g., yellow jacket wasps). Surveillance of potential areas of concern is a critical element for directing and responding to potential outbreaks of mosquitoes and the potential for conveying mosquito-borne diseases.

Impact HH-1: No impact would occur to human health from the use of the Surveillance Alternative.

7.2.4 Physical Control Alternative

Physical Control for mosquitoes consists of the management of mosquito-producing habitat (including freshwater marshes and lakes, saltwater marshes, temporary standing water, and wastewater treatment facilities) especially through water control and maintenance or improvement of channels, tide gates, levees, and other water control facilities. Physical control is usually the most effective mosquito control technique because it provides a long-term solution by reducing or eliminating mosquito developmental sites and ultimately reduces the need for chemical applications. The physical control practices may be categorized into three groups: maintenance, new construction, and cultural practices. The District performs these physical control activities in accordance with all appropriate environmental regulations (wetland fill and dredge permits, endangered species review, water quality review, streambed alteration permits, etc.), and in a manner that generally maintains or improves habitat values for desirable species. Physical control for other vectors such as rodents is based on the District's site inspections to determine conditions promoting infestation, and property owners are provided educational materials on control measures that include removal of food sources and professionals to contact to remove the infestation. Physical control techniques have minimal impact on humans due to prior identification and avoidance of potential problem areas and wildlife habitats by publishing scheduled treatment times and locations. For physical control measures used for onsite wastewater treatment systems, see Section 9.2.4.

Impact HH-2: Impacts to human health from use of the Physical Control Alternative would be **less than significant** and mitigation is not required.

7.2.5 Vegetation Management Alternative

The District uses hand tools (e.g., shovels, pruners, chain saws, and weed-whackers) and heavy equipment where necessary for vegetation removal or thinning and sometimes applies herbicides to improve surveillance or reduce vector habitats. Vegetation removal or thinning primarily occurs in aquatic habitats to assist with the control of mosquitoes and in terrestrial habitats to help with the control of other vectors and facilitate access to mosquito-breeding habitat. To reduce the potential for mosquito breeding associated with water retention and infiltration structures, District staff may systematically clear or trim

weeds and other obstructing vegetation in wetlands and retention basins (or request the structures' owners to perform this task). These tasks are performed in conjunction with discussions with appropriate agencies (including CDFW) about special-status species and their habitats that must be acknowledged and protected prior to these activities being conducted. Vegetation management is also performed to assist other agencies and landowners with the management of invasive/nonnative weeds for control of mosquito breeding habitat. These actions are typically performed under the direction of the concerned agency, which also maintains any required permits. These activities are conducted during predetermined times of recreational inactivity to provide an additional measure of safety to the public.

> **Impact HH-3: No impact** would occur to human health from the nonherbicide Vegetation Management Alternative.

7.2.5.1 Herbicides

The herbicides the District may consider for future use would be applied in strict conformance with label requirements. Herbicides are discussed in Appendix B, and those that have been identified for additional evaluation are described below. Herbicides would be used to control vegetation in and around mosquito habitats to improve access needed for surveillance and to reduce potential habitat for mosquitoes. These herbicides are listed in Table 7-4 and discussed in detail in the indicated sections of Appendix B.

Table 7-4 Herbicides Used for Mosquito Abatement

Active Ingredient	Appendix B
Imazapyr	Section 4.6.1
Glyphosate	Section 4.6.2
Triclopyr	Section 4.6.3

Herbicides being considered for the Program have diverse chemical structures act through distinct modes of action, and exhibit varying levels of potential toxicity to humans and nontarget species. Certain herbicides are nonselective and broad-spectrum, such as imazapyr. Herbicides used against annual broadleaf weeds are generally of the post-emergent variety, such as triclopyr. In addition, imazapyr is a systematic, nonselective, pre- and post-emergent herbicide used for a broad range of terrestrial and aquatic weeds. Glyphosate represents a commonly used herbicide for the control and elimination of grass weeds and sedges. Most of the herbicides are moderately persistent in soil and water (for each herbicide's half-life in soil and water, please refer to Appendix B).

Imazapyr (USEPA 2006b) and triclopyr (USEPA 1998) have been shown to exhibit no/low toxicity to humans. Furthermore, the actual use and human exposure in the field are far less than tested in the laboratory and much higher volumes (exposure) would be needed to result in toxicity.

> **Impact HH-4:** Impacts to human health from the herbicides imazapyr and triclopyr would be **less than significant** and mitigation is not required.

Glyphosate is a nonselective, post-emergent, and systemic herbicide that is the active ingredient (as an acid or salt) in Alligare, Aquamaster, Buccaneer, and Roundup© products. It is designed to target the shikimic acid pathway, which is specific to plants and some microorganisms; therefore, glyphosate is thought to have very low toxicity to mammals (USEPA 1993). The District employs an adequate buffer to water sources when it applies glyphosate. It is further mediated by the techniques used for application. Typically, application does not occur when wind is 5 mph or greater or within 15 feet of a crop area or sensitive habitat.

The USEPA classifies glyphosate as Category III for oral and dermal toxicity (USEPA 1993), and the isopropylamine and ammonium salts exhibit low toxicity to mammals via the oral and dermal routes. A 1-

year feeding study resulted in no chronic effects in beagles at daily doses of 500 mg/kg (USEPA 1993). Currently, no published scientific evidence indicates that glyphosate is carcinogenic or mutagenic except in specific instances where workers are exposed to extended industrial uses (USEPA 1993) or some unpublished claims of sublethal effects (Gertsberg 2011). It is poorly biotransformed in rats and is excreted via feces and urine; neither the parent compound nor its major breakdown product bioaccumulates in animal tissue (Williams et al. 2000).

Despite the apparent lack of toxicity to mammals, concerns have been raised about glyphosate's long-term developmental and reproductive effects. Although still in review, glyphosate is included in the final list of chemicals for screening under USEPA's Endocrine Disruptor Screening Program (USEPA 2009a). The issue of endocrine-disrupting compounds is a topic of current scientific concern and inquiry. Recently, the USEPA renewed the temporary approval of a glyphosate and 2-4-D combination product (Enlist-Duo) for use with weed vectors, indicating it has not received significant adverse data to negate the decision (USEPA 2014b). Only very high exposures to those chemicals suggested as endocrine disruptors can be shown to suggest a linkage. Because this exposure linkage is so high, endocrine disruption in a human would require, if real, exposure to substantially higher levels of the chemical than that used for vector control. It is likely that USEPA will provide an updated review of its potential risks in 2015. However, current data indicate that glyphosate is nontoxic to humans, and the endocrine disruption issue is not clear at this time. Glyphosate products are effective, widely used, generally low risk products used for weed control (Gertsberg 2011). Some reports in the press of sublethal effects on disease resistance, biological diversity, or enzyme activity as a result of ingestion/uptake of genetically engineered foods are interesting but without clear mechanisms that can be related directly to glyphosate (Gertsberg 2011).

The District strictly adheres to herbicide application BMPs and product label requirements, including the restriction of glyphosate application to targets outside an approved (by USFWS) or other commonly used buffer zone separating water sources, which reduces the potential for impacts to special-status species or other nontarget receptors including humans. Targeted, small-scale treatments are conducted to minimize post-application drift and runoff, which minimizes exposure to humans near targeted areas.

> **Impact HH-5:** Impacts to human health from the use of glyphosate would be **less than significant** and mitigation is not required.

7.2.5.2 Adjuvants

An adjuvant is any compound that is added to a pesticide/herbicide formulation or tank mix to facilitate the mixing, application, or effectiveness of that product. FIFRA does not require testing and registration of adjuvants. As such, little information on their fate, transport, and toxicity exists, other than that provided by the manufacturer or published by the scientific community (Bakke 2007; Tu et al. 2001). CDPR does require the registration of adjuvants that are considered to increase the action of the pesticides with which they are used (Bakke 2007). The adjuvants the District employs and where they are used can be found in detail in Appendix B and listed in Table 7-5 except for aliphatic polycarboxylate.

Table 7-5 Adjuvants Used for Weed Abatement

Active Ingredient	Appendix B
APEs	Section 4.7.1
Modified Plant Oil and Methylated Seed Oil	Section 4.7.3
Lecithin (phosphatidylcholine)	Section 4.7.4
Aliphatic Polycarboxylate	Not included

Alkylphenol ethoxylates (APEs) are used as detergents, dispersants, emulsifiers, solubilizers, and foaming and wetting agents. Primary degradation of APEs in the environment generates more persistent shorter chain compounds, some of which may mimic natural hormones and disrupt endocrine function in humans (Ying et al. 2002). Nonylphenol and nonylphenol ethoxylate, which are produced in large volumes and widely used, exhibit low acute oral and dermal toxicity but are highly irritating and corrosive to the skin and eyes (USEPA 2010). The acute toxicity of APEs to mammals is low; however, concern exists regarding the estrogen-mimicking behaviors of these compounds, particularly nonylphenol and nonylphenol ethoxylate (USEPA 2010). The USEPA (2010) has recently recommended that this suite of chemicals be evaluated further due to their widespread use, persistence, and possible estrogen-mimicking behavior.

Plant-derived oils are of two types: triglycerides or methylated oils. Triglycerides are essentially oil-surfactant hybrids and are generally called seed oils. Plant-derived oils (from soybeans, cottonseeds, etc.) decrease surface tension, but they are not as effective as other surfactants at increasing spreading, sticking, or penetration. Modified plant oils and methylated seed oils are essentially nontoxic to most organisms, including plants. Little is known of the environmental fate of these adjuvants.

Little is known about the toxicity or environmental fate of lecithins. Lecithins are naturally occurring phospholipids in biological cell membranes (Bakke 2007). Although toxicity and environmental fate information for these products is scarce, using BMP application practices including application at the lowest effective concentration for a specific set of vectors and environmental conditions, use of lecithins should not result in unwanted adverse effects to humans.

Aliphatic polycarboxlyates are another category of adjuvants that are essentially nontoxic to biota and are used as an additive to enhance the efficacy of several other products. They are listed as having no known toxicity or adverse biological impacts as a polymer additive with no hazard indications in any of the typical categories used to define toxicity by regulators. (Kegley et al. 2014)

BMPs the District employs include using adjuvants in limited amounts in areas that do not contain special-status species, coordination with CDFW, USFWS, and/or NMFS before conducting management activities in sensitive habitat, keeping spray nozzles within a predetermined maximum distance of target insect or weeds (e.g., within 24 inches of vegetation for hand application), and preventing exposures to nontarget habitats (post-application) including human use areas.

> **Impact HH-6:** Impacts to human health from the use of pesticide adjuvants would be **less than significant** and mitigation is not required.

7.2.6 Biological Control Alternative

Biological control of mosquitoes and other vectors involves the intentional use of vector pathogens (diseases), parasites, and/or predators to reduce the population size of target vectors. Biological control is used as a method of protecting the public from mosquitoes and the diseases using mosquito parasites, pathogens, and predators. At present, mosquito parasites are not commercially available for mosquito control.

7.2.6.1 Mosquito Larvae Pathogens

As part of their Biological Control Alternative, the District employs bacterial larvicides that are highly specific to mosquitoes. These biological controls include Bs, Bti, and may include spinosad in the future. Because the potential environmental impacts of Bs or Bti application are generally similar to those of chemical pesticide applications, these materials and spinosad are evaluated below under Section 7.2.7, Chemical Control Alternative. The environmental fate and toxicity of these control agents is discussed in Appendix B.

7.2.6.2 Mosquito Predators

Mosquitofish (*Gambusia affinis*) are presently the only commercially available mosquito predators. The District's stocking of these fish in mosquito habitats is the most commonly used biological control agent for mosquitoes in the world. Used correctly, this fish can provide safe, effective, and persistent suppression in various mosquito sources. However, due to concerns that mosquitofish may potentially impact red-legged frog and tiger salamander populations, the District limits the use of mosquitofish to ornamental fish ponds, water troughs, water gardens, fountains, unused swimming pools, and other types of isolated man-made ponds that do not provide habitat that could support native species.

Impact HH-7: No impact would occur to human health from the use of mosquitofish.

7.2.6.3 Other Vectors

No effective natural predators exist to control high rodent populations. Domestic and feral cats may provide short-term control when the rodent population is low, but they can also impact bird populations. The District does not employ cats for rat control. Currently, no commercial biological control agents or products are available for wasp, yellow jacket, and tick control.

7.2.7 Chemical Control Alternative

The Chemical Control Alternative would be a continuation of existing activities using applicable techniques, equipment, vehicles, watercraft, and aircraft.

Chemical control is a Program tool that consists of the application of nonpersistent insecticide products demonstrated to reduce populations of larval or adult mosquitoes and other invertebrates (e.g., yellow jacket wasps, ticks). If and when inspections reveal that mosquitoes or other vector populations are present at levels that trigger the District's guidelines for chemical control – based on the vector's abundance/density, species composition, proximity to human settlements, water temperature, or presence of predators – the District applies pesticides to the site in strict accordance with label instructions and federal and state guidelines.

Most of the chemical controls the Program uses are for mosquito abatement and vector control and are classified as larvicides or adulticides. Below is a discussion of the larvicides, adulticides, and other insecticides the District uses. The active ingredients that were identified as warranting further evaluation in Appendix B due to their potential toxicity and/or prevalent use/public concerns are listed in Table 7-6. (Herbicides were discussed previously in Section 7.2.5.)

Table 7-6 Active Ingredients Identified for Further Evaluation in Appendix B

Active Ingredient	Vector	Potential Issue / Concern
Methoprene	Mosquitoes	Prevalent use; toxicity to aquatics and insects
Etofenprox	Mosquitoes, yellow jacket wasps	Toxicity to aquatic organisms; no synergist required
Bti	Mosquitoes	Prevalent use; public concerns
Pyrethrins	Mosquitoes	Prevalent use; requires synergist (PBO)
Resmethrin	Mosquitoes	Requires synergist (e.g., PBO); potential endocrine disruptor
Aliphatic solvents Plant-derived oil/mineral oil mix	Mosquitoes	Contains low percentage of petroleum distillate
Permethrin	Mosquitoes	Toxicity to aquatic organisms; potential endocrine disruptor

7.2.7.1 *Mosquito Larvicides*

Larvicides are used to manage immature life stages of mosquitoes including larvae and pupae in aquatic habitats. For example, larvicide application(s) can be necessary in temporary aquatic habitats that do not have adequate populations of predators (e.g., fish) or habitats with dense and/or abundant populations of emergent or floating vegetation that can support mosquito production. The larvicides are applied using ground application equipment, watercraft, fixed-wing aircraft, and rotary aircraft. District guidelines for selecting application methods are predicated upon access, efficiency and effectiveness of application, size of the area to be treated, and the density and type of vegetation present at the application site (i.e., the likelihood of success in applying the material to the target area). All of the potential treatment options are considered and weighed to select the most appropriate options prior to use, and physical control and chemical treatment may both be used in the target area. District staff may choose to treat soil and/or surface water in the vicinity of an onsite wastewater treatment system that appears to have failed or malfunctioned due to improper lid seals, cracks, or missing vent screens and/or due to drain fields where water ponds on the surface. In this situation, the District may provide selected mosquito larvicide treatment to the tank and/or the septic leach/drain field and system environs. The larvicides currently used include materials not known to adversely impact septic system bacteria: *Bacillus sphaericus* as an active ingredient (e.g., VectoLex), methoprene, (e.g., Altosid briquets), larvicide oils (e.g., BVA 2 and CocoBear), and monomolecular films (e.g., Agnique MMF).

The mosquito larvicides the District uses and where they are used is discussed in detail in Appendix B are listed in Table 7-7: bacterial larvicides, hydrocarbon esters, and surfactants.

Table 7-7 Chemicals Employed for Larval Mosquito Abatement

Chemical Classification	Active Ingredient	Appendix B
Bacterial larvicide	Bs	Section 4.3.1
Bacterial larvicide	Bti	Section 4.3.2
Bacterial larvicide	Spinosad	Section 4.3.3
Hydrocarbon ester	Methoprene	Section 4.3.4
Surfactant	Alcohol Ethoxylated Surfactant (monomolecular film)	Section 4.3.5
Surfactant	Aliphatic Hydrocarbons (mineral oil)*	Section 4.3.6

* CocoBear Oil is a plant-based oil that combines coconut oil with a small amount of mineral oil (10 percent). It is discussed in Section 4.3.6.4 in Appendix B as a mosquito larvicide. Other plant-derived and methylated seed oils are discussed in Section 4.7.3 as adjuvants in Appendix B.

7.2.7.1.1 Bacterial Larvicides (Bs, Bti, and Spinosad)

Bacterial larvicides such as Bs and Bti are highly selective microbial pesticides (for mosquitoes) that, when ingested, produce gut toxins that cause destruction of the insect gut wall leading to paralysis and death. These pathogens multiply rapidly in the host, destroying internal organs and consuming nutrients. The pathogen can be spread to other mosquito larvae in some cases when larval tissue disintegrates and the pathogens are released into the water and are ingested by uninfected larvae. Bs and Bti, produce proteins that are toxic to most mosquito larvae, while the fermentation of *S. spinosa* produces spinosyns, which are highly effective mosquito neurotoxicants. All three bacteria are naturally occurring soil organisms and are commercially produced as mosquito larvicides. Bs can reproduce in natural settings for some time following release. Bs and Bti are applied on a variety of crops and standing and moving waterbodies, Bti materials the District applies do not contain live organisms, only spores. The spores of Bs and Bti can persist in the environment for months, but the endotoxins are readily degraded by UV light

and persist for a few to several days (relatively short half- life). Bacterial spores of Bti are uniquely toxic to nematoceran Diptera (mosquitoes, midges, blackflies, psychodids, and ceratopogonids) (Lacey and Mulla 1990). Both Bs and Bti do not exhibit any human toxicity.

Spinosad alters nicotine acetylcholine receptors in insects, causing constant involuntary nervous system impacts ultimately leading to paralysis and death. It is used on various crops, animal husbandry premises, recreation areas, rights-of-way, and local residences. The USEPA has classified spinosad as a "reduced risk" compound because it is an alternative to more toxic, OP insecticides (CDPR 2002). It exhibits very low acute toxicity by all exposure routes and has not been shown to elicit chronic toxicity in humans.

Impact HH-8a: No impact would occur to human health from the use of bacterial larvicides.

7.2.7.1.2 Hydrocarbon Ester - Methoprene

Methoprene is an insect growth regulator and effective larvicide. It used in a variety of settings including indoors and outdoors at residences, animal husbandry premises, industrial sites, irrigation systems, and standing waterbodies. It is applied either in response to observed high populations of mosquito larvae at a site, or as a sustained-release product that can persist for 4 months or longer if a site has limited accessibility and has regularly produced immature mosquitoes in the past. It is applied using hand equipment, ATVs, watercraft, or by low-flying helicopters and potentially fixed-wing aircraft (particularly for marshes and other highly vegetated areas) but never when winds exceed 10 mph to prevent drift. The larger droplet sizes of aerial (e.g., helicopter) larvicide applications (e.g., methoprene) can reduce drift (compared to that of ULV applications). In addition, aerial treatments are restricted to times when wind is non-existent or at acceptable levels. Methoprene is generally applied in extremely small amounts during treatments due to its efficacy against mosquitoes even at low concentrations. For example, the District applies it at a maximum concentration of 4.8 µg/L. Methoprene is also sometimes co-applied with Bti (i.e., Duplex) to prevent resistance and ensure all larval stages are controlled. See Section 9.2.7.1 for discussion of use of methoprene in malfunctioning onsite wastewater treatment systems due to improper lid seals, cracks, or missing vent screens and/or due to drain fields where water ponds on the surface.

Methoprene has very low acute toxicity to humans and mammals by all routes (USEPA 1991a). No potentially significant impact exists to humans by exposure to typical application levels of methoprene. To achieve toxicity to humans, exposures hundreds of times higher than legally allowed for use in vector control would be required, and such exposure would need to be extensive. It is of public concern due to its widespread use and unsubstantiated reports of potential nontarget impacts (discussed in Chapter 6, Section 6.2.7.1.2).

Impact HH-8b: No impact would occur to human health from the use of the mosquito larvicide methoprene.

7.2.7.1.3 Surfactants

The monomolecular film formulation used as a surfactant in California for mosquito larvae control is Agnique, an alcohol ethoxylated surfactant. Monomolecular films are low toxicity pesticides that spread a thin film on the water surface that makes it difficult for mosquito larvae, pupae, and emerging adults to attach to the water's surface, causing them to drown (USEPA 2007). The films also disrupt larval respiration of some other classes of air-breathing aquatic insects. They are used on an assortment of waterbodies including ornamental ponds, pastures, irrigation systems, drainage systems, and drinking water systems (CDPR 2010). Monomolecular films are not environmentally persistent and may typically degrade within 21 days. No evidence supports that these alcohol ethoxylated surfactants are toxic to humans.

Surfactants could result in temporary reductions to populations of surface-breathing insects (other than mosquitoes) during treatment; however, it is unlikely that these reductions would result in lasting or observable effects on nontarget organisms when applied within product label limits (Peterson et. al.,

2006). In addition, populations recover quickly following recolonization from adjacent and neighboring sites and habitats (Lawler and Lanzaro 2005).

Aliphatic solvents are often used when monomolecular films (alcohol ethoxylated surfactants) do not provide sufficient mosquito control. They also break down more rapidly (2 to 3 days) and are practically nontoxic to most nontarget organisms. They have a low degree of acute toxicity to mammals. Therefore, mineral oil should not result in adverse effects to human health when applied using District pesticide application BMPs.

Plant oil mixes include the use of a small amount of a mineral oil-alcohol ethoxylated surfactant and a blend of methyl esters of fatty acids.

Plant-derived oils, whether vegetable or fruit, can be used as adjuvants that enhance the effectiveness of herbicides or as surfactants for the management of vectors, especially immature mosquitoes. Plant-derived oils are generally of two types: triglycerides or methylated oils. CocoBear Mosquito Larvicide Oil is the only plant-based oil that is currently available for use in the District's Program (also see Section 4.3.6.4 in Appendix B). This product consists mostly of a modified coconut oil (75 percent or more by volume) combined with 10 percent by volume mineral oil and a very small amount of nonionic surfactant and other proprietary ingredients. This material can be used in various waterbodies such as ditches, stagnant pools, swamps, marshes, temporary rainwater pools and intermittently flooded areas, ponds, catch basins, and man-made containers for the management of immature mosquitoes. CoCoBear has no reported significant toxicity to any receptors likely to be exposed during or after use as a larvicide. Acute oral toxicity to rats is >5,000 mg/kg, acute dermal toxicity to rats is >5,050 mg/kg, and acute inhalation toxicity to rats is >2.16 mg/L (Clarke 2014).

> **Impact HH-8c: No impact** would occur to human health from the use of surfactant larvicides (alcohol ethoxylated surfactant and aliphatic solvents).

7.2.7.2 Mosquito Adulticides

The District may use pesticides for control of adult mosquitoes as a component of the IVMP. For example, adulticides would be used when other tools are not effective or appropriate and adult mosquito control guidelines are met, including species composition, abundance (as measured by landing count or other quantitative method), proximity to human populations, and/or human disease risk. Adulticide materials are used only as needed to control adult mosquito populations. The adulticides the District uses to control mosquitoes, ticks, and yellow jacket wasps and the scenarios when they are used is discussed in detail in Appendix B and are listed in Table 7-8. Control of yellow jacket wasps and ticks are also discussed in Section 7.2.7.3.

Table 7-8 Chemicals Employed for Adult Vector/Insect Abatement

Chemical Classification	Active Ingredient	Vector	Appendix B
Pyrethrin	Pyrethrins	Mosquito; yellow jacket	Section 4.1.1
Pyrethroid	Allethrins and d-*trans* allethrin	Mosquito; yellow jacket; tick	Section 4.1.2
Pyrethroid	Phenothrin (sumithrin or d-phenothrin)	Mosquito; yellow jacket	Section 4.1.3
Pyrethroid	Prallethrin	Mosquito; yellow jacket	Section 4.1.4
Pyrethroid	Deltamethrin	Mosquito; yellow jacket; tick	Section 4.1.5
Pyrethroid	Esfenvalerate	Yellow jacket wasp; tick	Section 4.1.6
Pyrethroid	Resmethrin	Mosquito	Section 4.1.8
Pyrethroid	Tetramethrin	Mosquito; yellow jacket	Section 4.1.9

Table 7-8 Chemicals Employed for Adult Vector/Insect Abatement

Chemical Classification	Active Ingredient	Vector	Appendix B
Pyrethroid	Permethrin	Mosquito; yellow jacket	Section 4.1.10
Pyrethroid	Etofenprox	Mosquito	Section 4.1.11
Synergist	PBO	Mosquito; yellow jacket	Section 4.1.12

7.2.7.2.1 Pyrethrins

Pyrethrins are naturally occurring compounds distilled from the flowers of certain Chrysanthemum species. They effectively induce temporary paralysis in insects but are not acutely lethal by themselves; thus, they are typically used concomitantly with the synergist PBO, which inhibits metabolism of the pyrethrins so that a lethal dose is assured (USEPA 2006c). The District uses pyrethrins on crops, animal husbandry premises and pastures, outdoor household areas, and for wide-area mosquito abatement in areas that include aquatic habitats.

Pyrethrins have low to moderate acute mammalian toxicity via the oral, dermal, and inhalation routes (Categories III and IV, see Table 6-1, Appendix B). They are a moderate eye irritant (Category III), a mild dermal irritant (Category IV), and not a skin sensitizer. The effects of pyrethrins are (1) neurobehavioral effects following acute, short-term, and chronic exposure, with nervous system lesions observed in the rat and mouse following acute exposure; (2) thyroid effects, following chronic exposure in the rat and dog; and (3) liver effects, following short- and long-term exposure in the rat, dog, and mouse. The neurobehavioral effects are considered relevant to humans because the effects are observed in both the rat and mouse, and the mode of action affects a basic function of the nervous system that is common to all animals (USEPA 2006c). Several studies have shown that pyrethrins applied using ULV techniques do not accumulate in water or sediment following repeated applications. These studies also determined that no toxicity is associated when exposure is limited to the amounts used when following ULV protocols for mosquito control (Lawler et al. 2008; Amweg et al. 2006).

Pyrethrins are of concern because they are used prevalently and require the use of the synergist PBO, a potential endocrine disruptor (USEPA 2009a). However, the District uses pyrethrins only when absolutely necessary and in minimal amounts in ULV applications that are designed to break down rapidly, resulting in very low potential exposure to humans and domestic animals (BMPs H3, H4, H11). As an additional measure, pyrethrin applications are canceled during less than ideal wind and potential drift conditions (BMP H6). For wasp (yellow jacket and paper wasps) control, the District applies pyrethrins in minute volumes directly to ground and tree nests,

> **Impact HH-9:** Impacts to human health from the use of pyrethrins would be **less than significant** and mitigation is not required.

7.2.7.2.2 Pyrethroids, Pyrethroid-Like Compounds, and Synergists

Pyrethroids are synthetic compounds that are chemically similar to the pyrethrins but have been modified to increase stability and activity against insects. Pyrethroids bind to neuronal voltage-gated sodium channels, preventing them from closing; this persistent activation of the channels then leads to paralysis.

First generation or “Type I” pyrethroids include d-allethrin, phenothrin (sumithrin), prallethrin, resmethrin, and tetramethrin. These pyrethroids are used to control flying and crawling insects in a number of commercial and horticultural applications and are sold for residential use and application on pets to control fleas and ticks. They have effective insect knock-down capabilities but are unstable as they are highly photosensitive (i.e., easily degraded by light). The newer second-generation/”Type II” pyrethroids

contain an α-cyano group, which reduces their photosensitivity, thereby increasing their persistence and toxicity. The active ingredients that fall into this group include deltamethrin, esfenvalerate, and permethrin.

Some synthetic insecticides are similar to pyrethroids, such as etofenprox, but have a slightly different chemical composition. The pyrethroids that were identified for further evaluation in Appendix B are discussed below.

7.2.7.2.3 Resmethrin

Resmethrin is the active ingredient in Scourge®. It is a restricted-use pesticide due to its toxicity to fish and is available for use only by certified pesticide applicators or persons under their direct supervision.

Resmethrin has low acute toxicity via the oral (Category III), dermal (Category III), and inhalation (Category IV) routes of exposure. Resmethrin is included in the final list of chemicals for screening under USEPA's Endocrine Disruptor Screening Program (USEPA 2009a).

Though public concern regarding resmethrin exists because of its potential endocrine-disrupting properties and concomitant use of PBO, Scourge® is rarely used and is being phased out of the District's program and replaced with a nonresmethrin alternative.

7.2.7.2.4 Permethrin

Permethrin is also a pyrethroid. Dermal exposure in humans can cause tingling and pruritus with blotchy erythema on exposed skin (ATSDR 2003). In humans, acute effects observed subsequent to ingestion of permethrin included nausea, vomiting, abdominal pain, headache, dizziness, anorexia, and hypersalivation. Reports of severe poisoning are rare and usually follow ingestion of substantial, but poorly described, amounts of permethrin. Symptoms of severe poisoning include impaired consciousness, muscle fasciculation, convulsions, and noncardiogenic pulmonary edema (ATSDR 2003). Systemic effects are similar to those seen in acute and chronic ingestion with prolonged contact or contact with high concentrations of permethrin. Acute toxicity to permethrin via inhalation has been shown to be very small. The USEPA (2006c) has classified permethrin as Category III for acute oral and acute dermal toxicity, Category III for eye irritation potential, and Category IV for dermal irritation potential.

Because permethrin is included in the final list of chemicals for screening under USEPA's Endocrine Disruptor Screening Program (USEPA 2009a), it is of concern to the public. However, the District rarely uses it, applies it through ULV application with a backpack mister or hand can/duster, and does not apply during high winds. Risk assessments provided in support of product registration indicate that the acute risk quotients for terrestrial mammals are below the USEPA's acute levels of concern. (USEPA 2009b).

7.2.7.2.5 Etofenprox

Etofenprox is a pyrethroid-like insecticide that is the active ingredient in Zenivex®. It differs in structure from pyrethroids in that it lacks a carbonyl group and has an ether moiety, whereas pyrethroids contain ester moieties. Under general use by homeowners, it can be used indoors, as a spot treatment for pets, and as an outdoor fogger to control flying and crawling insect pests in backyards and patios. The District applies it to aquatic habitats/outdoors. It has low acute toxicity to humans and mammals. The District strictly adheres to application BMPs, such as monitoring of sites post–treatment (BMP H11) and product label requirements. Etofenprox is generally applied during the nighttime hours, pre-dawn and at dusk when sensitive receptors such as honeybees are not active (BMP H12), and in general, people are not active at these times either.

> **Impact HH-10:** Impacts to human health from the use of pyrethroids and pyrethroid-like compounds as mosquito adulticides would be **less than significant** and mitigation is not required.

7.2.7.2.6 Piperonyl Butoxide

PBO is a pesticide synergist that enhances the effectiveness of pesticide active ingredients, such as pyrethrins and pyrethroids, by inhibiting microsomal enzymes and, thus, the breakdown of the other active ingredient(s) (USEPA 2006a). It is a registered active ingredient in products used to control flying and crawling insects and arthropods in agricultural, residential, commercial, industrial, and public health settings. No products contain only PBO. It degrades quickly in soil and water. PBO has a low acute toxicity by oral, inhalation, and dermal routes, but it is included in the final list of chemicals for screening under USEPA's Endocrine Disruptor Screening Program (USEPA 2009a). As a synergist, PBO is applied using the same guidelines as those for pyrethroids and pyrethrins: ULV application with a backpack mister or hand can/duster, and it is not applied during high winds, which minimizes the exposure of people to this synergist.

> **Impact HH-11:** Impacts to human health from the use of the synergist PBO in mosquito adulticides would be **less than significant** and mitigation is not required.

7.2.7.3 Yellow Jacket Wasp and Tick Adulticides

The District selectively applies insecticides to control ground-nesting yellow jackets that pose an imminent threat to people or pets. The District does not currently perform control work with respect to tick populations but may potentially do a limited amount of control work in the future using esfenvalerate. This activity would likely be triggered by public or agency requests for District assistance or action rather than as a result of regular surveillance of their populations. The District does not apply pesticides to yellow jacket populations that are located in or on a structure. Whenever the District learns that a hive is situated in or on a structure or is above ground, the resident(s) are encouraged to contact a private pest control company that is licensed to treat the infestation. Yellow jacket nests that are off the ground would be treated only under special circumstances to protect public health and safety of the District's residents. When a District technician encounters a honeybee swarm or unwanted hive, residents are referred to the County Agricultural Commissioner's Office, which maintains a referral list of beekeepers that can safely remove the bees. If a District technician deems it appropriate to treat stinging insects, they will apply the insecticide directly within the nest in accordance with the District's policies to avoid drift of the insecticide or harm to other organisms. Alternatively, they will place tamper-resistant traps or bait stations, selective for the target insect in the immediate environment of the vector. The pesticides the District uses to control yellow jacket wasps are shown in Table 7-8.

Pyrethroid-based chemicals are typically used against ground-nesting yellow jackets and are applied directly into the underground nest, which prevents drift and further reduces the potential for nontarget exposure to these compounds. Also their active ingredients consist largely of pyrethrins (a photosensitive natural insecticide manufactured from a Chrysanthemum species), or allethrin, and phenothrin (first generation synthetic pyrethroids with similar photosensitive, nonpersistent characteristics as pyrethrin). The potential environmental impacts of these materials are minimal. See Section 7.2.7.2.1 and impact HH-9 which covers the use of pyrethrins for yellow jackets. See Sections 7.2.7.2.2 and impact HH-10 which covers the use of pyrethroids for yellow jacket and tick control.

7.2.8 Other Nonchemical Control/Trapping Alternative

The trapping of rodents and/or yellow jackets may be conducted in the future when these organisms pose a threat to public health and welfare. For both vector species, District staff would place the tamper-resistant or baited trap(s) primarily at the request of the property owner, manager, or agency. The District does not remove rats or yellow jackets that are in or on structures. When these structural requests are made, residents are referred to the local animal control or to a directory of private pest control companies. No impact to human health is expected from the District's use of this alternative.

> **Impact HH-12: No impact** would occur to human health from the District's use of the Other Nonchemical Control/Trapping Alternative.

7.2.9 Cumulative Impacts

"Cumulative impacts" are defined as "two or more individual effects which, when considered together, are considerable or compound or increase other environmental impacts (CEQA Guidelines, Section 15355). Cumulative impacts, as they relate to human health, include past, present, and reasonably foreseeable actions that potentially impact humans. Cumulative impacts can result from individually minor, but collectively significant, projects taking place over a period of time. The cumulative impact analysis is contained in Section 13.5 and focuses on the potential for the use of pesticides for mosquito and vector control to contribute to regional pesticide use, which is of concern for its potential impacts to the health of human populations. It includes Table 13-1, Historical Pesticide Use within the Marin-Sonoma Mosquito and Vector Control District's Program Area for 2006-2010 and Table 13-2, Pesticide Use within the Marin-Sonoma Mosquito and Vector Control District's Service Area.

Although large uncertainty and high variation exist in the reported amounts of pesticide use within the District's Program Area counties, they vary according to particular needs, majority of habitat type, and seasonal vector outbreaks. The District uses BMPs in their pesticide applications for mosquito and vector control and is attempting to reduce total pesticide use where possible consistent with IVM practices.

The District's incremental contributions to overall pesticide use within its Program Area are not substantial and do not trigger a cumulatively considerable impact on pesticide use. While overall use of pesticides throughout the Program Area may be considered cumulatively significant, the District's small incremental contributions to this impact are not cumulatively significant given use of BMPs to mitigate potential impacts. Therefore, the **Program's long-term activities including chemical applications would not contribute considerably to human health impacts.** The Program alternatives would not result in significant cumulative impacts to the human health condition of the region.

7.2.10 Environmental Impacts Summary

Table 7-9 presents a summary of human health impacts associated with the six alternatives. The human health impacts correspond to those in Sections 7.2.3 through 7.2.8. All of the impacts were determined to be either "no impact" or a "less-than-significant impact."

Table 7-9 Summary of Human Health Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Effects on Human Health						
Impact HH-1: No impact would occur to human health from the use of the Surveillance Alternative.	N	na	na	na	na	na
Impact HH-2: Impacts to human health from use of the Physical Control Alternative would be **less than significant** and mitigation is not required.	na	LS	na	na	na	na
Impact HH-3: No impact would occur to human health from the nonherbicide Vegetation Management Alternative.	na	na	N	na	na	na
Impact HH-4: Impacts to human health from the herbicides imazapyr and triclopyr would be **less than significant** and mitigation is not required.	na	na	LS	na	na	na
Impact HH-5: Impacts to human health from the use of glyphosate would be **less than significant** and mitigation is not required.	na	na	LS	na	na	na
Impact HH-6: Impacts to human health from the use of pesticide adjuvants would be **less than significant** and mitigation is not required.	na	na	LS	na	na	na
Impact HH-7: No impact would occur to human health from the use of mosquitofish.	na	na	na	N	na	na
Impact HH-8a: No impact would occur to human health from the use of bacterial larvicides.	na	na	na	na	N	na
Impact HH-8b: No impact would occur to human health from the use of the mosquito larvicide methoprene.	na	na	na	na	N	na
Impact HH-8c: No impact would occur to human health from the use of surfactant larvicides (alcohol ethoxylated surfactant and aliphatic solvents).	na	na	na	na	N	na
Impact HH-9: Impacts to human health from the use of pyrethrins would be **less than significant** and mitigation is not required.	na	na	na	na	LS	na

Table 7-9 Summary of Human Health Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact HH-10: Impacts to human health from the use of pyrethroids and pyrethroid-like compounds as mosquito adulticides would be **less than significant** and mitigation is not required.	na	na	na	na	LS	na
Impact HH-11: Impacts to human health from the use of the synergist PBO in mosquito adulticides would be **less than significant** and mitigation is not required.	na	na	na	na	LS	na
Impact HH-12: No impact would occur to human health from the District's use of the Other Nonchemical Control/Trapping Alternative.	na	na	na	na	na	N

LS = Less-than-significant impact
N = No impact
na = Not applicable
SM = Potentially significant but mitigable impact
SU = Significant and unavoidable impact

7.2.11 Mitigation and Monitoring

All impacts to human health are identified as either “no impact” or a “less-than-significant impact.” Therefore, mitigation measures are not applicable to the insignificant impacts identified for all of the Program alternatives described.

8 Public Services and Hazard Response

Chapter 8 evaluates potential impacts to public services and hazard response from the Program implementation. Results of the evaluation are provided at the programmatic level. Section 8.1, Environmental Setting, presents an overview of the public services and hazard response in the Program Area, and contains state and local ordinances and regulations that are applicable to the Program. Section 8.2, Environmental Impacts and Mitigation Measures, presents the following:

> Environmental concerns and evaluation criteria: A determination of whether the Program alternatives would cause significant impacts to public services and hazard response

> Evaluation methods and assumptions

> Discussion of the impacts from the Program alternatives, and recommendations for mitigation, if required, for those impacts

> Cumulative impacts summary

> A summary of environmental impacts to public services and hazard response

8.1 Environmental Setting

8.1.1 Overview of Public Services and Hazard Response

The District operates in accordance with its Injury and Illness Prevention Program that has been updated (MSMVCD 2015) and its Hazardous Release and Pesticide Spill Response Procedures (MSMVCD 2014). The District provides safety training by field supervisors for all employees who may be affected by any substance, process, procedure, or equipment that represents a potential hazard. These plans and procedures provide BMPs for minimizing the impact of small spills of hazardous materials, storage of hazardous materials, and worker safety in the field conducting surveillance, physical control, vegetation management, and pesticide/herbicide application protocols. These BMPs are listed in Table 2-6 and repeated in Section 8.2.2.2. In 2012, the District had zero incidents requiring spills management, zero incidents involving worker safety, and no fire incidents. The Proposed Program would continue activities subject to these plans and BMPs in the future, similar to the existing Program.

The District has regular safety training and equipment inspection meetings and several half-day to full day trainings as well. The Emergency Response Plan is contained in part in the documentation that the District submits annually to the California Environmental Reporting System (CERS) maintained by Cal/EPA. New employees take state examinations to be certified as mosquito, invertebrate, and vertebrate vector control technicians. To take the comprehensive exams, they receive extensive training. Once they have passed the exams they are enrolled in a continuing education program to maintain their certifications (20 hours per year). Additionally, employees also receive extensive ongoing training each year from the District concerning equipment and pesticide use, protecting sensitive species and habitats, emergency and safety procedures, first aid, minimizing fire hazards, etc.

A combination of county sheriffs' departments and municipal police departments provides law enforcement services in the Program Area. Sheriffs' departments typically provide law enforcement and jail services within their respective counties.

Additionally, the California Highway Patrol is the state police force for California. They have specific jurisdiction over all California state routes, US highways, interstate highways, and freeways in the state, and over all public roads in unincorporated parts of a county.

Fire protection services in the Program Area are provided by a number of agencies, including county fire departments, city fire departments, and fire districts. A number of counties also have volunteer fire departments.

California Department of Forestry and Fire Protection (CAL FIRE) oversees the fire protection and stewardship of over 31 million acres of California's privately owned wildlands. CAL FIRE's firefighters, fire engines, and aircraft respond to an average of more than 5,600 wildland fires each year. CAL FIRE also responds in other emergency situations such as medical aid, hazardous material spills, swift water rescues, search and rescue missions, civil disturbances, train wrecks, floods, earthquakes, and more. CAL FIRE provides varied emergency services in 36 of California's 58 counties via contracts with local governments.

8.1.2 Regulatory Setting

California state law and local ordinances and regulations pertaining to public services and hazard response are cited in this section. No federal regulations pertain to public services or hazard response. Regulations governing human health are discussed in Chapter 7, *Human Health*.

8.1.2.1 State

8.1.2.1.1 California Code of Regulations (CCR)

CCR Title 3 Division 6, Pesticides and Pest Control Operations, directs the safe use and transport of pesticides within the state. The following are some of the sections of particular relevance to the Proposed Program:

> ***6670. Container Control***
>
> *Pesticides, emptied containers or parts thereof, or equipment that holds or has held a pesticide, shall not be stored, handled, emptied, disposed of, or left unattended in such a manner or at any place where they may present a hazard to persons, animals (including bees), food, feed, crops or property. The [Agricultural] commissioner may take possession of such unattended pesticides or emptied containers to abate such hazard.*
>
> ***6672. Delivery of Pesticide Containers***
>
> *(a) No person shall deliver a container that holds, or has held, a pesticide to a property unless he stores it in an enclosure or closure complying with the requirements of this Section or delivers it to a person in charge of the property or his agent, or a pest control operator or his employee. The person receiving the container shall control access to it in accordance with this Section.*
>
> *(b) Each person who controls the use of any property or premises is responsible for all containers or equipment on the property that hold, or have held, a pesticide. Unless all such containers are under his personal control so as to avoid contact by unauthorized persons, he shall:*
>
> *(1) Provide a person responsible to him to maintain such control over the containers at all times; or*
>
> *(2) Store all such containers in a locked enclosure, or in the case of liquid pesticides in a container larger than 55 gallons in capacity, the container shall have a locked closure. Either shall be adequate to prevent unauthorized persons from gaining access to any of the material.*

6682. Transportation

(a) Pesticides shall not be transported in the same compartment with persons, food or feed.

(b) Pesticide containers shall be secured to vehicles during transportation in a manner that will prevent spillage onto the vehicle or off the vehicle. Paper, cardboard, and similar containers shall be covered when necessary to protect them from moisture.

8.1.2.1.2 California Department of Forestry and Fire Protection

Public Resources Code 4201-4204 directs CAL FIRE to map fire hazards within State Responsibility Areas based on relevant factors such as fuels, terrain, and weather. These statutes were passed after significant wildland-urban interface fires occurred; consequently, these hazards are described according to their potential for causing ignitions to buildings. These zones, referred to as Fire Hazard Severity Zones (FHSZs), provide the basis for application of various mitigation strategies to reduce risks to buildings associated with wildland fires (CAL FIRE 2007).

Additionally, the Public Resources Code, beginning with Section 4427, includes fire safety regulations that restrict the use of equipment that may produce a spark, flame, or fire; require the use of spark arrestors on construction equipment with internal combustion engines; specify requirements for the safe use of gasoline-powered tools in fire hazard areas; and specify fire suppression equipment that must be provided on site for various types of work in fire-prone areas. These requirements would apply to Program activities within a "Very High Fire Hazard Severity Zone."

8.1.2.2 Local

Local ordinances and regulations are usually contained within the general plans of cities and counties in the Program Area, and focus on providing adequate public services and hazard response with a reasonably brief response time throughout each agency's service area. Municipal and county ordinances establish police and fire departments and districts, and some establish emergency preparedness councils or committees. Marin County Environmental Health Services identifies potentially dangerous and unhealthy situations and promotes sound environmental health practices through education and the enforcement of public health statutes and regulations in Marin County. Protecting the health and well-being of individuals and the community in Sonoma County is the fundamental responsibility of the Sonoma County Department of Health Services.

8.2 Environmental Impacts and Mitigation Measures

The impacts evaluation for public services and hazard response is provided below. The evaluation analyzes the Program's impacts relative to the impact significance criteria presented in Section 8.2.1.

8.2.1 Evaluation Concerns and Criteria

The following concerns were associated with public services and hazard response and are addressed in this section:

> Risk of spill of hazardous materials from equipment/vehicles or applications of pesticides and/or herbicides

> Risk of aerial equipment failure during applications of pesticides

> Safe storage and disposal of chemical-related materials including pesticide containers

For this evaluation, Program impacts would be considered potentially significant according to the CEQA environmental checklists for Public Services (XIV) and Hazards and Hazardous Materials (VIII), if any of the Program alternatives would:

> Result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts in order to maintain acceptable service ratios, response time or other performance objectives for any of the public services:
  - Fire protection
  - Police protection
  - Schools
  - Parks
  - Other public facilities
> Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment;
> Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school;
> Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5, and, as a result, would create a significant hazard to the public or the environment; or
> Expose people or structures to a significant risk of loss, injury, or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands.

The other criteria contained in the CEQA checklist are not listed because they are not relevant to the impact analysis in this chapter for the Proposed Program for the following reasons. Program could result in the application of certain pesticide treatments within 0.25 mile of an existing or proposed school; the potential for hazardous effects of the Program alternatives on sensitive populations are discussed in Chapter 7, *Human Health*. Public services and hazard response to impacts at or near schools would be the same as described under the first criterion listed above.

Although activities proposed under the Program alternatives could occur on or near sites included on a list of hazardous materials sites (e.g., landfills and manufacturing sites) compiled pursuant to Government Code Section 65962.5 (Cal/EPA 2013), most of these activities, with the exception of constructing new shallow ditches or minor water control features, would not involve excavation or other ground disturbance that could result in impacts related to the release of materials at these hazardous materials sites. However, the District maintains a database of existing hazardous materials sites within its Service Area.

One of the Program alternatives involves aerial application of chemical treatments by helicopter (and potentially fixed wing aircraft in the future) and could, therefore, occur partially within areas covered by airport land use plans, within 2 miles of public airports or public use airports, or within the vicinity of private airstrips. However, no construction or other activities would occur that would conflict with airport land use plans or result in a safety hazard for people residing or working in proximity to these facilities. Therefore, this criterion is not applicable to the Program and is not discussed further.

None of the Program alternatives would result in any road or lane closures or detours. The Program would not involve activities that could impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan. Therefore, this criterion is not applicable to the Program and is not discussed further.

Under some of the Program alternatives, the District and its registered contractors would practice safe disposal of pesticide products. Properly rinsed empty containers can be safely and legally disposed of at landfills. Any unused portions of Program chemicals would be disposed of at permitted hazardous waste

collection locations. Adequate landfill and hazardous waste collection capacity exists in locations throughout the Program Area. The Program would not exceed the existing capacity to safely dispose of these materials. Therefore, this criterion is not applicable to the Program and is not discussed further.

Based on public concerns and the relevant CEQA criteria above, the environmental impact topics addressed in the impact analyses are:

a. Increase Demand for Police, Fire, or Health-Care Services
b. Create a Significant Hazard to the Public or Environment
c. Expose People or Structures to Wildfire Risk

8.2.2 Evaluation Methods and Assumptions

The methodology and assumptions of this impact evaluation for the Program alternatives are provided below.

8.2.2.1 Methodology

The methodology used to prepare this public services and hazard response impact section is as follows:

> Reviewed transcripts from public scoping meetings on the PEIR in June 2012.

> Summarized federal, state, county, and select municipal regulations, ordinances, and guidelines for general public services and hazard response issues and as they related to the Program.

> Evaluated potential hazards requiring response and potential interference with public services and hazard response at the programmatic level.

> Determined probable impacts and mitigation measures associated with the alternatives proposed in Chapter 2, *Program Description*.

8.2.2.2 Assumptions

For the analysis of potential impacts to public services and hazard response, no assumptions were made beyond those explained in Chapter 2, *Program Description*, for the Program alternatives. They include the following BMPs (see Table 2-6) that are applicable to all of the Program alternatives:

> Equip all vehicles used in wildland areas with a shovel and/or a fire extinguisher during the fire season. (BMP J1)

> Train employees on the safe use of equipment and machinery, including vehicle operation. (BMP J2)

> District will regularly review and update the existing health and safety plan to maintain compliance with all applicable standards. Employees will be required to review these materials annually. (BMP J3)

> A hazardous spill plan will be developed, maintained, made available, and staff trained on implementation and notification for petroleum-based or other chemical-based materials prior to commencement of vector treatment activities. (BMP I5)

Additional spill management BMPs for use of herbicides and pesticides under the Vegetation Management and Chemical Control Alternatives are:

> Exercise adequate caution to prevent spillage of pesticides during storage, transportation, mixing, or application of pesticides. Report all pesticide spills and cleanups (excepting cases where dry materials may be returned to the container or application equipment). (BMP I1)

> Maintain a pesticide spill cleanup kit and proper protective equipment at the District's Service Yard and in each District truck used for pesticide transport. (BMP I2)

> Manage the spill site to prevent entry by unauthorized personnel. Contain and control the spill by stopping it from leaking or spreading to surrounding areas, cover dry spills with polyethylene or plastic tarpaulin, and absorb liquid spills with appropriate absorbent materials. (BMP I3)

> Properly secure the spilled material, label the bags with service container labels identifying the pesticide, and deliver them to a District/Field Supervisor for disposal. (BMP I4)

> Field-based mixing and loading operations will occur in such a manner as to minimize the risk of accidental spill or release of pesticides. (BMP I6)

Under CEQA, the term "impact" is used to mean an adverse or negative effect from a physical change in the environment compared to existing conditions.

8.2.3 Surveillance Alternative

The Surveillance Alternative involves both ground surveillance and water surveillance. Surveillance activities include field investigations, trapping, sampling, and responding to public service requests. The number and type of vehicles and equipment required for surveillance would vary, but typically, ground surveillance would require the periodic use of light trucks, such as pickup trucks and jeeps, and low ground pressure ATVs, and would take place in all land use types. Water surveillance would require the use of ATVs and, occasionally, boats and most frequently would occur in agricultural and open-space areas. Most equipment would only be operated a few hours per day for varying periods of time throughout the year. Pesticide use is limited; only small amounts of chemicals are used for trapping purposes (i.e., Dichlorvos-containing solid paper "fragments" that are used in mosquito collection jars). However, the potential for a fuel spill exists. For spills of fuel less than or greater than 5 gallons, the District will follow procedures contained in the District's Hazardous Release and Pesticide Spill Response Procedures (2014).

8.2.3.1 Increase Demand for Police, Fire, or Health-Care Services

It is unlikely that the Surveillance Alternative would result in a substantial increase in requests for services from emergency dispatchers and responders, and the Program would not adversely affect the ability of 9-1-1 dispatchers to handle calls.

> **Impact PSH-1**: Surveillance activities would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.

8.2.3.1.1 Create a Significant Hazard to the Public or Environment

Surveillance activities, including the use of vehicles for site access and monitoring and very small amounts of pesticides or attractants in containers, would not create a significant hazard to the public or the environment. District staff would adhere to all applicable CCR requirements regarding pesticides and to trap label instructions. The District's Injury and Illness Prevention Program has been updated (MSMVCD 2015) and provides safety training by field supervisors for all employees who may be affected by any substance, process, procedure, or equipment that represents a potential hazard. The MSMVCD employee training and safety programs and the CDPH Vector Control Technician training/certification, and continuing education programs, are conducted for the safe use of equipment, machinery, or tools and the safe use and disposal of pesticides. While under training, employees are required to take comprehensive examinations and are enrolled subsequently in a continuing education program reviewed and supervised by CDPH. District staff also are responsible for implementing the District's Hazardous Release and Pesticide Spill Response Procedures (MSMVCD 2014) if needed.

Adherence to CCR requirements and District BMPs to minimize spills (BMP I1 through I6) reduces the potential for accident conditions; therefore, the Surveillance Alternative would not result in significant hazards to the public or environment.

Impact PSH-2: Surveillance activities would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.

8.2.3.1.2 Expose People or Structures to Wildfire Risk

Surveillance vehicles could be used in moderate to very high FHSZs. Ground surveillance requires the periodic use of light trucks, such as pickup trucks and jeeps, and ATVs, but does not require the use of large-scale, offroad equipment. In addition, surveillance is conducted via existing roads and access routes except when existing routes are unavailable and offroad access is required. All vehicles used in wildland areas are equipped with a shovel and/or a fire extinguisher during the fire season (BMP J1). The District's Illness and Injury Prevention Program, Spill Response Procedures, and employee manuals provide training for all employees on the safe use of equipment and machinery, including vehicle operation (BMP J2). After completing the training, employees are required to take comprehensive examinations and are enrolled in a continuing education program. Vegetation management to provide access to surveillance sites also reduces the risk of fire from equipment use. These measures will reduce fire hazards; therefore, the Surveillance Alternative is not likely to increase wildfire hazards through the use of equipment that may produce a spark, flame, or fire and would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires.

Impact PSH-3: Surveillance activities would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.

8.2.4 Physical Control Alternative

The Physical Control Alternative involves managing vector habitat to reduce vector production or migration and typically reduces the need for pesticides. Vector management is accomplished primarily through direct habitat management and public education. Physical control for mosquitoes consists of managing wetlands and waterbodies through maintenance, new construction, and cultural practices such as the installation and maintenance of water control facilities, sediment and debris removal, vegetation maintenance and removal, and the construction and maintenance of ditches or installation of culverts that eliminate mosquito-breeding habitat. The District can also require landowners to conduct similar maintenance activities for mosquito abatement. All such requests result in the District instructing the landowner of the need to consult with resource agencies about the potential for special-status species, protection of wetlands and sensitive habitats, and the need for any permits prior to commencement of work. Physical controls for mammal vectors include reducing food sources and reducing conditions that promote harborage.

The number and type of vehicles and equipment required for physical control would vary by activity, but typically, terrestrial activities would require the periodic use of light trucks, such as pickup trucks and jeeps, and ATVs. Wetland and aquatic activities would require the use of ATVs and, occasionally, boats and sprayers. The potential for a fuel spill exists. For spills of fuel less than or greater than 5 gallons, the District will follow procedures contained in the District's Hazardous Release and Pesticide Spill Response Procedures (2014).

8.2.4.1.1 Increase Demand for Police, Fire, or Health-Care Services

The level of activity in the future is similar to existing conditions. It is unlikely that the Physical Control Alternative would result in a substantial increase in requests for services from emergency dispatchers and responders, and the Program would not adversely affect the ability of 9-1-1 dispatchers to handle calls.

Impact PSH-4: Physical control activities would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.

8.2.4.1.2 Create a Significant Hazard to the Public or Environment

Physical control activities involve equipment use but do not include the use of pesticides and herbicides and are intended to reduce the need to use chemical control measures for mosquito and/or vector control; District BMPs include management of fuel spills. Therefore, the Physical Control Alternative would not create a significant hazard to the public or the environment.

> **Impact PSH-5:** Physical control activities do not include the use of pesticides or herbicides; therefore, these activities would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.

8.2.4.1.3 Expose People or Structures to Wildfire Risk

Physical control requires the use of vehicles and equipment that could be used in moderate to very high FHSZs. Access to work sites requires the periodic use of light trucks, such as pickup trucks and jeeps, and ATVs. Physical control activities are conducted via existing roads and access routes except when existing routes are unavailable and offroad access is required. Construction or maintenance of ditches, levees, or other features could also require the use of large-scale, offroad equipment. Power tools are also used for vegetation management. The District's Illness and Injury Prevention Program, Spill Response Procedures, employee manuals, California Vector Control Certification Technician program, CDPH Continuing Education Program, and ongoing in-house safety programs provide training for all employees on the safe use of equipment, tools, and machinery, including vehicle operation. While undergoing training, employees are required to take comprehensive examinations and are enrolled in a continuing education program. All vehicles are equipped with a shovel and/or a fire extinguisher during the fire season. These measures will reduce fire hazards; therefore, the Physical Control Alternative is not likely to increase wildfire hazards through the use of equipment that may produce a spark, flame, or fire and would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires.

> **Impact PSH-6:** Physical control activities would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.

8.2.5 Vegetation Management Alternative

Vegetation management activities are conducted to reduce the value of mosquito habitat and to allow District access for inspections and treatment. The number and type of vehicles and equipment required would vary by activity, but typically, access to vegetation management areas would require the periodic use of light trucks, such as pickup trucks and jeeps, and ATVs. Access and herbicide application at or near aquatic areas (if used in the future) would require the use of ATVs and, occasionally, boats and sprayers. For potential spills of fuel and/or herbicides less than or greater than 5 gallons, the District will follow procedures contained in the District's Hazardous Release and Pesticide Spill Response Procedures (MSMVCD 2014).Vegetation management activities require the use of hand tools or other mechanical means (i.e., heavy equipment) for vegetation removal or thinning. Herbicide applications, which may be considered in the future, would be used at waste ponds and in natural habitats. Vegetation removal or thinning primarily occurs in or adjacent to aquatic habitats to allow access to sources of mosquito production or control mosquitoes and in terrestrial habitats to control other vectors. To reduce the potential for mosquito breeding associated with water retention and infiltration structures, District staff may systematically clear weeds and other obstructing vegetation in wetlands and retention basins (or request the structures' owners to perform this task). Tools ranging from shovels and pruners to chainsaws and weed-eaters up to heavy equipment can all be used at times to clear plant matter that either prevents access to mosquito-breeding sites or that prevents good water management practices that would minimize mosquito populations and the potential for mosquito-borne disease transmission. Generally, however, District vegetation management

activities rely almost entirely on hand tools. Trimmed vegetation is either removed and disposed of properly from the site or broadcast in such a way as to minimize visual degradation of the habitat. Trimming is also kept to a minimum to reduce the possibility of the invasion of exotic plant and animal species. Water control structures are also used to manage vegetation by manipulating hydroperiods.

8.2.5.1.1 Increase Demand for Police, Fire, or Health-Care Services

The level of activity in the future is similar to existing conditions. It is unlikely that the Vegetation Management Alternative would result in a substantial increase in requests for services from emergency dispatchers and responders, and the Program would not adversely affect the ability of 9-1-1 dispatchers to handle calls.

> **Impact PSH-7:** Vegetation management activities would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.

8.2.5.1.2 Create a Significant Hazard to the Public or Environment

The routine transport, use, or disposal of herbicides for vegetation management activities would not create a significant hazard to the public or the environment. Applicators would adhere to all applicable CCR requirements regarding pesticides to ensure safety. The District's Illness and Injury Prevention Program (MSMVCD 2015) provides safety training for all employees who may be affected by any substance, process, procedure, or equipment that represents a potential hazard. Training programs are conducted for the safe use of equipment, machinery, or tools and the safe use and disposal of pesticides and herbicides. While in training, employees are required to take comprehensive examinations and are enrolled in a continuing education program reviewed and supervised by CDPH.

The Hazardous Release and Pesticide Spill Response Procedures (MSMVCD 2014) address any release of a potentially hazardous material or nontarget discharge (spill) of pesticides into the environment. All spills of herbicides or fuel would be handled according to the District's procedures for cleanup of small spills of 5 gallons or less and for larger spills as follows:

> Adequate caution shall be exercised to prevent spillage of pesticides during storage, transportation, mixing or application of pesticides. All pesticide spills and cleanups (excepting cases where dry materials may be returned to the container or application equipment) shall be reported using the District's database application.

> A pesticide spill cleanup kit and proper protective equipment will be maintained at the Vector Control Service Yard and in each vehicle used for pesticide application or transport.

> The spill site should be managed to prevent entry by unauthorized personnel. The spill will be contained and controlled by stopping it from leaking or spreading to surrounding areas, and dry spills will be covered with polyethylene or plastic tarpaulin and liquid spills will be absorbed with appropriate absorbent materials.

> Absorb the material and place in an appropriate container for proper disposal if the release is less than 5 gallons. If spill is greater than 5 gallons, dike and dam to prevent further spread, manage the site as best and safely as possible until help arrives.

> The spilled material will be properly secured and the bags will be labeled with service container labels identifying the pesticide and delivered to a Field Supervisor for disposal.

Adherence to CCR requirements and the District's spill cleanup procedures reduce the potential for accident conditions; therefore, the Vegetation Management Alternative would not result in significant hazards to the public or environment.

> **Impact PSH-8:** Vegetation management activities would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous

materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.

8.2.5.1.3 Expose People or Structures to Wildfire Risk

Vehicles and power tools could be used in moderate to very high FHSZs during vegetation management activities. Power tools include leaf blowers, mowers, chainsaws, and weed-eaters. Access to sites and vegetation management requires the periodic use of light trucks, such as pickup trucks and jeeps, and ATVs, and could require the use of large-scale, offroad equipment such as tractors. Access will be via existing roads and access routes except when existing routes are unavailable and offroad access is required. The District's Injury and Illness Prevention Program, employee manuals, Continuing Education Program (CDPH), and ongoing in-house safety programs provide training for all employees on the safe use of tools, equipment, and machinery, including vehicle operation. While in training, employees are required to take comprehensive examinations and are enrolled in a continuing education program reviewed and supervised by CDPH. All vehicles are equipped with a shovel and/or a fire extinguisher during the fire season. These measures will reduce fire hazards; therefore, the Vegetation Management Alternative is not likely to increase wildfire hazards through the use of equipment that may produce a spark, flame, or fire and would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires.

Impact PSH-9: Vegetation management activities would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.

8.2.6 Biological Control Alternative

The Biological Control Alternative involves the use of pathogens and predators to reduce mosquito populations. Biological control is not used for controlling other vectors. Mosquito pathogens include bacteria and viruses specifically targeted to mosquitoes which do not pose a risk to public health. Insects, fish, birds, and bats are predators used for biological control of mosquitoes. Mosquitofish (*Gambusia affinis*) are the most commonly used biological control agent throughout the world and the primary means of control used by the District. Biological control requires the periodic use of light trucks, and occasionally, ATVs, boats, tractors, helicopters, and sprayers. For spills of fuel less than or greater than 5 gallons, the District will follow procedures contained in the District's Hazardous Release and Pesticide Spill Response Procedures (2014).

The use of biological control reduces the need to use pesticides, but the use of pathogens usually involves application methods similar to chemical treatment. Examples of bacteria pathogenic to mosquitoes are Bs, the several strains of Bti, and *Saacharopolyspora spinosa (*spinosad*)*. Because the potential environmental impacts of Bs or Bti application are generally similar to those of chemical pesticide applications, these materials and spinosad are evaluated under the Chemical Control Alternative. The analysis below is focused on the use of mosquitofish in, artificial aquatic habitats such as water troughs and ornamental fish ponds.

8.2.6.1.1 Increase Demand for Police, Fire, or Health-Care Services

The level of activity in the future is similar to existing conditions. It is unlikely that the Biological Control Alternative would result in a substantial increase in requests for services from emergency dispatchers and responders, and the Program would not adversely affect the ability of 9-1-1 dispatchers to handle calls.

Impact PSH-10: Biological control activities would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.

8.2.6.1.2 Create a Significant Hazard to the Public or Environment

Biological control activities do not include the use of pesticides and herbicides or other hazardous materials other than fuel for trucks, but currently rely on mosquitofish, and are intended to reduce the need to use chemical control measures. For spills of fuel less than or greater than 5 gallons, the District will follow procedures contained in the District's Hazardous Release and Pesticide Spill Response Procedures (2014). Mosquitofish are used in controlled environments to avoid their migration into habitats used by sensitive species. District policy is to limit their use to contained water sources, such as ornamental fish ponds, water troughs, water gardens, fountains, and unused swimming pools. Therefore, the Biological Control Alternative would not create a significant hazard to the public or the environment.

> **Impact PSH-11:** Biological control activities would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.

8.2.6.1.3 Expose People or Structures to Wildfire Risk

Vehicles could be used to access areas or to release or apply mosquitofish in areas that are moderate to very high FHSZs. Access requires the periodic use of light trucks, such as pickup trucks and jeeps, and ATVs, but does not require the use of large-scale, offroad equipment. Access for biological control will be via existing roads and access routes except when existing routes are unavailable and offroad access is required. The District's Illness and Injury Prevention Program, employee manuals, Continuing Education Program (CDPH), and continuous in-house safety training program provide training for all employees on the safe use of equipment and machinery, including vehicle operation. While in training, employees are required to take comprehensive examinations and are enrolled in a continuing education program. All vehicles are equipped with a shovel and/or a fire extinguisher during the fire season. These measures will reduce fire hazards; therefore, the Biological Control Alternative is not likely to increase wildfire hazards through the use of equipment that may produce a spark, flame, or fire and would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires.

> **Impact PSH-12:** Biological control activities would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.

8.2.7 Chemical Control Alternative

Chemical control is a Program tool that consists of the application of relatively nonpersistent insecticides that due to active ingredient, application rate, and/or application method are largely specific to mosquitoes and directly reduce populations of larval or adult mosquitoes and other invertebrate threats to public health (e.g., ticks, yellow jacket wasps). Chemical control is implemented when inspections reveal that mosquitoes or other vector populations are present at levels that trigger the District's guidelines for chemical control based on the vector's abundance, density, species composition, proximity to human settlements and recreation areas, water temperature, presence of predators and other factors. The potential for a pesticide or fuel spill exists. For spills of material less than or greater than 5 gallons, the District will follow procedures contained in the District's Hazardous Release and Pesticide Spill Response Procedures (2014b).

The majority of chemical control tools are used for mosquito abatement and consist of larvicides and adulticides. Mosquito larvicides routinely used by the District include Bti, Bs, Methoprene (e.g., Altosid), CoCoBear Oil, BVA-2, and Agnique. Adulticides used by the District include pyrethrins (Pyrocide®) and synthetic pyrethroids such as etofenprox (Zenivex®). The District may potentially use adulticides, such as Pyrenone (25-5®), Pyrenone Crop Spray®, and Permethrin (Kontrol 4-4), and synthetic pyrethroids, including Resmethrin (Scourge®), which is being phased out of the Program. Mosquito adulticide materials are used when necessary to control mosquito populations.

Pyrethroid-based chemicals are typically used against ground-nesting yellow jackets and ticks, and this control measure is usually triggered by public requests. When the District treats stinging insects, staff will apply the insecticide directly within the nest in accordance with the District's policies to avoid drift of the insecticide or harm to other organisms. Alternatively, the District may place tamper-resistant traps or bait stations (if available and appropriate in the future), selective for the target insect in the immediate environment of the vector. The potential environmental impacts of these materials is minimal due to two factors: (1) their active ingredients consist largely of pyrethrins (a photosensitive natural insecticide manufactured from a Chrysanthemum species), or allethrin and phenothrin (first generation synthetic pyrethroids with similar photosensitive, nonpersistent characteristics as pyrethrin); and (2) the mode of their application for yellow jacket population control (i.e., directly into the underground nest), which prevents drift and further reduces the potential for inadvertent exposure to these materials.

8.2.7.1 Mosquito Ground Application

For ground larviciding, the District uses a variety of techniques and equipment to apply larvicides, including handheld sprayers, backpack sprayers, and blowers, and truck- or ATV-mounted spray rigs. The District uses conventional pickup trucks, and ARGO and other four-wheeled motorcycle-type ATVs as ground larvicide vehicles. ATV safety and handling is provided to employees before operating these machines. Ground larviciding allows applications while in close proximity to the actual treatment area, and consequently treatments occur to only those micro habitats where larvae are actually present, reducing the pesticide load on the environment compared to aerial application. However, risk of chemical exposure is also greater for the applicators during ground larviciding than during aerial larviciding.

Adulticiding is the only known effective measure of reducing an adult mosquito population in a timely manner. The most common form of adulticide application is ground adulticiding via insecticide applied at very low dosages (i.e., micron sized particles), which is referred to as the ULV (Ultra Low Volume) method. This method employs specially designed ULV equipment mounted on trucks, ATVs, golf carts, and boats or handheld for ground applications. Cold aerosol generators, cold foggers, and ULV machines are constructed by mounting a vortex nozzle on the forced air blower of a thermal fogger. Insecticide is applied as technical material or at moderately high concentrations (as is common with the pyrethroids) which translates to very small quantities per acre. In agriculture, this rate is assumed less than 36 ounces per acre, but mosquito control ground adulticiding operations rarely exceed 1 ounce per acre. The optimum sized droplet for mosquito control with cold foggers applied at ground level has been determined to be in the range of 10 to 30 microns.

8.2.7.1.1 Increase Demand for Police, Fire, or Health-Care Services

The level of activity in the future is similar to existing conditions. Occasional calls to the District or to emergency personnel could occur from the public in the treatment area due to concerns about the potential for impacts and need to stay indoors (or not), especially when a large-scale application is planned for an imminent and severe threat to public health. (Most calls are for information on dealing with vector problems and requests for service.) When performing large-scale operations, the District will issue public notifications (24 to 48 hours in advance if possible) to local authorities (see BMP H13) and any known chemically sensitive individuals (who register with the District), prior to commencement of treatment operations. However, it is unlikely that the Chemical Control Alternative would result in a substantial increase in requests for actual services from emergency dispatchers and responders, and the Program would not adversely affect the ability of 9-1-1 dispatchers to handle calls.

> **Impact PSH-13:** Chemical control activities would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.

8.2.7.1.2 Create a Significant Hazard to the Public or Environment

The use, transport, and disposal of the pesticides would not create a significant hazard to the public or the environment. The District uses the Chemical Control method only when other alternatives are ruled out and after certain guidelines are met that require implementing the Chemical Control Alternative (ground larviciding and adulticiding). Ground larviciding allows applications while in close proximity to the actual treatment area and, consequently, treatments occur to only those microhabitats where larvae are actually present, reducing the pesticide load on the environment. Ground adulticiding employs specialized equipment that provides targeted control and applications at small quantities per acre and ULVs, reducing potential drift and nontarget exposure.

Applicators would adhere to all applicable CCR requirements regarding pesticides to ensure safety and strictly adhere to the specific label instructions for each pesticide (see Section 2.9.1 and Appendix B). District BMPs further reduce the potential for spills and accidental releases of fuel and pesticides. The District's Illness and Injury Prevention Program provides safety training for all employees who may be affected by any substance, process, procedure, or equipment that represents a potential hazard. Training programs are conducted for the safe use of equipment, machinery, or tools and the safe use and disposal of pesticides. While in training, employees are required to take comprehensive examinations and are enrolled in a continuing education program.

The Hazardous Release and Pesticide Spill Response Procedures (2014) address any release of a potentially hazardous material or nontarget discharge (spill) of pesticides into the environment. All pesticide spills would be handled according to the District's procedures for cleanup of small spills of 5 gallons or less and for larger spills as follows:

> Adequate caution shall be exercised to prevent spillage of pesticides during storage, transportation, mixing or application of pesticides. All pesticide spills and cleanups (excepting cases where dry materials may be returned to the container or application equipment) shall be reported using the District's database application.

> A pesticide spill cleanup kit and proper protective equipment will be maintained at the Vector Control Service Yard and in each District truck used for pesticide transport.

> The spill site should be managed to prevent entry by unauthorized personnel. The spill will be contained and controlled by stopping it from leaking or spreading to surrounding areas, and dry spills will be covered with polyethylene or plastic tarpaulin and liquid spills will be absorbed with appropriate absorbent materials.

> Absorb the material and place in an appropriate container for proper disposal if the release is less than 5 gallons. If spill is greater than 5 gallons, dike and dam to prevent further spread, manage the site as best and safely as possible until help arrives.

> The spilled material will be properly secured and the bags will be labeled with service container labels identifying the pesticide and delivered to a Field Supervisor for disposal.

> Applicators must wear a P-95 disposable filtering face piece respirator for spill of Bs and Bti dry formulations.

Adherence to pesticide label instructions and the District's small spill cleanup procedure reduces the potential for accident conditions to affect the public or the environment; therefore, ground larviciding and adulticiding under the Chemical Control Alternative would not result in significant hazards to the public or environment. See also Sections 6.2.7 and 7.2.7.

> **Impact PSH-14:** Chemical control ground larviciding and adulticiding activities for mosquitoes would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably

foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.

8.2.7.1.3 Expose People or Structures to Wildfire Risk

Chemical control vehicles and equipment used for ground larviciding and adulticiding could be used in moderate to very high FHSZs. The District would use a variety of vehicles and equipment for access to sites and to apply ground larvicides and adulticides, including conventional pickup trucks and ATVs, blowers, and truck- or ATV-mounted spray rigs. Access to sites is via existing roads and access routes except when existing routes are unavailable and offroad access is required. The District's Illness and Injury Prevention Program provides training for all employees on the safe use of tools, equipment, and machinery, including vehicle operation. While in training, employees are required to take comprehensive examinations and are enrolled in a continuing education program. All vehicles are equipped with a shovel and/or a fire extinguisher during the fire season. These measures will reduce fire hazards; therefore, the Chemical Control Alternative is not likely to increase wildfire hazards through the use of equipment that may produce a spark, flame, or fire and would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires.

Impact PSH-15: Chemical control ground larviciding and adulticiding activities would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.

8.2.7.2 Mosquito Aerial Application

When large areas (areas that are especially difficult to access or with barriers to larvicide treatment, such as dense and abundant aquatic vegetation) are individually or simultaneously producing mosquito larvae at densities exceeding District treatment guidelines, then the District may use helicopters or other aircraft to apply any of the larvicides. Aerial application of larvicides is a relatively infrequent activity for the District, with each application covering approximately 20 to 600 acres per operation. Aerial application can be more practical for remote or inaccessible areas than ground larviciding. However, risk of drift is greater with aerial applications, especially with liquid or ULV aerial larviciding and, consequently, potential risk of nontarget exposure is greater.

The aerial larvicides, excluding granular and pellet formulations, are typically combined with water and applied as a low volume wet spray mix at 5 gallons per acre or less and sometimes at 10 gallons per acre or more depending on site conditions. Aerial application of liquid larvicides typically occurs during daylight hours and at an altitude of approximately 50 feet or less above the treatment site. Granular and pellet formulations of larvicides are applied using a large mechanical spreader with a bucket that is beneath the aircraft or pods positioned on the sides of the aircraft with spreaders (e.g., Isolair® system) that can hold several hundred pounds of granules/material.

Aerial adulticiding is often the only means available to cover a very large area quickly in case of severe mosquito outbreaks or vector-borne disease epidemics, and aerial applications may be the only reliable means of gaining effective control in some areas. Two aerial adulticiding techniques are used in California: low volume and ULV applications. Low volume (<2 gallons per acre) applications are conducted with the pesticide diluted in light petroleum oils or water and as a rather wet spray. The size of the droplets reduces drift, thus limiting swath widths, and may not be ideal under certain circumstances for impinging on mosquitoes. The technique is compatible with equipment commonly used for aerial liquid larviciding.

A common aerial adulticiding technique applies the insecticide in a technical concentrate or in a very high concentration formulation as an ULV cold fog. Lighter aircraft, including helicopters, can be used because the insecticide load is a fraction of the other techniques. If the aircraft is capable of >120 knots, fine droplets can be created by the high speed air stream impacting the flow from hydraulic nozzles. Slower aircraft and most helicopters typically use some variety of rotary atomizers to create the required droplet

spectrum. ULV applications can be difficult to accurately place with any regularity. Without the visual cues, drift and settling characteristics can be difficult to assess.

The flight parameters for aerial adulticiding differ by program and technique. Some operations fly during hours of daylight. At these times, the pilots should be able to see towers and other obstructions as well as keep track of the spray plume. The aircraft can be flown at a less-than-200-foot altitude, which may make it easier to hit the target area. Other operations may be conducted in the dark of the night. The aircraft typically are flown between a 200- and 300-foot altitude. Swath widths vary from operation to operation but are normally set somewhere between 400 and 1,200 feet. Swaths are flown as close to perpendicular with the wind as is possible. A number of factors affect the spray-drift offset and settling such as wind speed, droplet size, aircraft wake turbulence, altitude, and even characteristics of the individual aircraft. Pilots rely somewhat on experience for determining this offset, and some use telltale smoke or paper markers for swath alignment.

One of the public concerns was regarding potential hazards from fuel dumping before landing, which is a procedure used to lighten an aircraft's weight in certain emergency situations. For instance, if a flight takes off at a maximum takeoff weight and then faces a situation where it must return to the departure airport (due to certain mechanical problems or a passenger medical issue), not enough time is available to consume the fuel meant for getting to the original destination, and the aircraft may be over the maximum landing weight to land back at the departure point. Fuel would be released before landing. Once released, fuel would trail behind the aircraft. Most aviation fuel is a derivative of kerosene, which evaporates rapidly in the atmosphere and rarely survives in liquid form to reach the earth's surface.

This issue does not apply to the District's use of helicopter (or fixed-wing aircraft in the future if needed). These aircraft are not equipped to dump fuel. Only very large aircraft such as 727s and 747s are equipped to dump fuel prior to an emergency landing.

8.2.7.2.1 Increase Demand for Police, Fire, or Health-Care Services

The level of activity in the future is similar to existing conditions. Occasional calls to the District or to emergency personnel could occur from the public in the treatment area. The District notifies the County Agricultural Department and other appropriate agencies, depending on the location of an application, such as the county sheriff's department, California Highway Patrol, local police departments, fire departments, and local airports prior to commencement of aerial operations with specific information that allows for rapid and easy processing of calls they might receive from concerned citizens.

However, it is unlikely that aerial application under the Chemical Control Alternative would result in a substantial increase in requests for services from emergency dispatchers and responders, and the Program would not adversely affect the ability of 9-1-1 dispatchers to handle calls.

> **Impact PSH-16:** Chemical control (aerial application) activities would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.

8.2.7.2.2 Create a Significant Hazard to the Public or Environment

The use, transport, and disposal of the pesticides would not create a significant hazard to the public or the environment. The District uses the Chemical Control method only when other alternatives are ruled out after certain criteria are met that require implementing the Chemical Control Alternative. Aerial application of larvicides and adulticides is a relatively infrequent activity for the District. Applicators would adhere to all applicable CCR requirements regarding pesticides to ensure safety and strictly adhere to the specific label instructions for each pesticide (see Section 2.9.1 and Appendix B). The District's Illness and Injury Prevention Program provides safety training for all employees who may be affected by any substance, process, procedure, or equipment that represents a potential hazard. Training programs are conducted for the safe use of equipment, machinery or tools, and use and disposal of pesticides. After completing the training, employees are required to take a comprehensive examination and are enrolled in a continuing education program.

The Hazardous Release and Pesticide Spill Response Procedures (2014) address any release of a potentially hazardous material or nontarget discharge (spill) of pesticides into the environment. All pesticide spills would be handled according to the District's procedures for cleanup of 5-gallon-or-less and for larger spills as follows:

> Adequate caution shall be exercised to prevent spillage of pesticides during storage, transportation, mixing or application of pesticides. All pesticide spills and cleanups (excepting cases where dry materials may be returned to the container or application equipment) shall be reported using the District's database application.

> A pesticide spill cleanup kit and proper protective equipment will be maintained at the Vector Control Service Yard and in each vehicle used for pesticide application or transport.

> The spill site should be managed to prevent entry by unauthorized personnel. The spill will be contained and controlled by stopping it from leaking or spreading to surrounding areas, and dry spills will be covered with polyethylene or plastic tarpaulin and liquid spills will be absorbed with appropriate absorbent materials.

> Absorb the material and place in an appropriate container for proper disposal if the release is less than 5 gallons. If spill is greater than 5 gallons, dike and dam to prevent further spread, manage the site as best and safely as possible until help arrives.

> The spilled material will be properly secured and the bags will be labeled with service container labels identifying the pesticide and delivered to the Field Supervisor for disposal.

> Applicators must wear a P-95 disposable filtering face piece respirator for spill of Bs and Bti dry formulations.

Adherence to pesticide label instructions and the District's spill cleanup procedure reduces the potential for accident conditions to affect the public or the environment; therefore, the Chemical Control Alternative would not result in significant hazards to the public or environment.

> **Impact PSH-17:** Chemical control (aerial application) activities would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.

8.2.7.2.3 Expose People or Structures to Wildfire Risk

Helicopters or other aircraft could be used in moderate to very high FHSZs for aerial application similar to existing conditions. However, continued flight operations would not pose increased fire risk in those zones, and the Program would not substantially increase the risk of wildfire from accidents; therefore, the Chemical Control (aerial application) Alternative is not likely to increase wildfire hazards through the use of equipment that may produce a spark, flame, or fire and would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires.

> **Impact PSH-18:** Chemical control (aerial application) activities would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.

8.2.7.3 Yellow Jackets and Ticks

8.2.7.3.1 Increase Demand for Police, Fire, or Health-Care Services

The level of activity in the future is similar to existing conditions. Treatment is highly localized and broad; area wide chemical applications would not occur under the Proposed Program. It is unlikely that the Chemical Control Alternative (for yellow jackets and ticks) would result in a substantial increase in

requests for services from emergency dispatchers and responders, and the Program would not adversely affect the ability of 9-1-1 dispatchers to handle calls.

> **Impact PSH-19:** Chemical control for yellow jackets and ticks would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.

8.2.7.3.2 Create a Significant Hazard to the Public or Environment

The use, transport, and disposal of the pesticides would not create a significant hazard to the public or the environment. The District uses the Chemical Control method only when other alternatives are ruled out after certain criteria are met that require implementing the Chemical Control Alternative. Applicators would adhere to all applicable CCR requirements regarding pesticides to ensure safety and strictly adhere to the specific label instructions for each pesticide (see Section 2.9.1 and Appendix B). The District's Illness and Injury Prevention Program provides safety training for all employees who may be affected by any substance, process, procedure, or equipment that represents a potential hazard. Training programs are conducted for the safe use of equipment, machinery, or tools and the safe use and disposal of pesticides and herbicides. While in training, employees are required to take comprehensive examinations and are enrolled in a continuing education program.

The Hazardous Release and Pesticide Spill Response Procedures (2014) address any release of a potentially hazardous material or nontarget discharge (spill) of pesticides into the environment. All small pesticide spills would be handled according to the District's procedures for cleanup of 5-gallon-or-less spills as follows:

> Adequate caution shall be exercised to prevent spillage of pesticides during storage, transportation, mixing or application of pesticides. All pesticide spills and cleanups (excepting cases where dry materials may be returned to the container or application equipment) shall be reported using the District's database application.

> A pesticide spill cleanup kit and proper protective equipment will be maintained at the Vector Control Service Yard and in each vehicle used for pesticide application or transport.

> The spill site should be managed to prevent entry by unauthorized personnel. The spill will be contained and controlled by stopping it from leaking or spreading to surrounding areas, and dry spills will be covered with polyethylene or plastic tarpaulin and liquid spills will be absorbed with appropriate absorbent materials.

> Absorb the material and place in an appropriate container for proper disposal if the release is less than 5 gallons. If spill is greater than 5 gallons (i.e., fuel, from vehicles only), dike and dam to prevent further spread, manage the site as best and safely as possible until help arrives.

> The spilled material will be properly secured and the bags will be labeled with service container labels identifying the pesticide and delivered to the Field Operations Support Specialist for disposal.

> Applicators must wear a P-95 disposable filtering face piece respirator for spill of dry formulations.

Consistent with existing conditions, the District's adherence to pesticide label instructions and the spill cleanup procedure reduces the potential for accident conditions to the public or the environment; therefore, the Chemical Control Alternative would not result in significant hazards to the public or environment.

> **Impact PSH-20:** Chemical control of yellow jackets and ticks would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.

8.2.7.3.3 Expose People or Structures to Wildfire Risk

Vehicles could be used in moderate to very high FHSZs similar to existing conditions. Access to application sites could require the periodic use of light trucks, such as pickup trucks and jeeps, and ATVs, but does not require the use of large-scale, offroad equipment. Access is via existing roads and access routes except when existing routes are unavailable and offroad access is required. The District's Illness and Injury Prevention Program provides training for all employees on the safe use of tools, equipment, and machinery, including vehicle operation (MSMVCD 2015). While in training, employees are required to take comprehensive examinations and are enrolled in a continuing education program. All vehicles are equipped with a shovel and/or a fire extinguisher during the fire season. These measures will reduce fire hazards; therefore, the Chemical Control Alternative is not likely to increase wildfire hazards through the use of equipment that may produce a spark, flame, or fire and would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires.

> **Impact PSH-21:** Chemical control of yellow jackets and ticks would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.

8.2.8 Other Nonchemical Control/Trapping Alternative

The Other Nonchemical Control/Trapping Alternative includes the use of tamper-resistant or baited traps to trap rodents and/or yellow jackets in the future, and on a limited basis, that pose a threat to public health and welfare. However, the potential for a fuel spill exists. For spills of fuel less than or greater than 5 gallons, the District will follow procedures contained in the District's Hazardous Release and Pesticide Spill Response Procedures (2014).

8.2.8.1.1 Increase Demand for Police, Fire, or Health-Care Services

The level of activity in the future is similar to existing conditions. It is unlikely that the Other Nonchemical Control/Trapping Alternative would result in a substantial increase in requests for services from emergency dispatchers and responders, and the Program would not adversely affect the ability of 9-1-1 dispatchers to handle calls.

> **Impact PSH-22:** Other Nonchemical Control/Trapping Alternative activities would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.

8.2.8.1.2 Create a Significant Hazard to the Public or Environment

Other Nonchemical Control/Trapping Alternative activities do not include the use or transport of pesticides that could spill or leak into the environment. For spills of fuel less than or greater than 5 gallons, the District will follow procedures contained in the District's Hazardous Release and Pesticide Spill Response Procedures (2014). Therefore, this alternative would not create a significant hazard to the public or the environment.

> **Impact PSH-23:** The Other Nonchemical Control/Trapping Alternative would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.

8.2.8.1.3 Expose People or Structures to Wildfire Risk

Other Nonchemical Control/Trapping Alternative activities could require operating vehicles in moderate to very high FHSZs. Access to sites could require the periodic use of light trucks, such as pickup trucks and jeeps, and ATVs, but would not require the use of large-scale, offroad equipment. In addition, access

would be via existing roads and access routes except when existing routes are unavailable and offroad access is required. The District's Illness and Injury Prevention Program provides training for all employees on the safe use of equipment, and machinery, including vehicle operation. While in training, employees are required to take comprehensive examinations and are enrolled in a continuing education program. All vehicles are equipped with a shovel and/or a fire extinguisher during the fire season. These measures will reduce fire hazards; therefore, the Other Nonchemical Control/Trapping Alternative is not likely to increase wildfire hazards through the use of equipment that may produce a spark, flame, or fire and would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires.

> **Impact PSH-24:** The Other Nonchemical Control/Trapping Alternative would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.

8.2.9 Cumulative Impacts

The District's Program would not incrementally increase demand for police, fire, or health-care services, nor would it create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials, through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment, or through the operation of aircraft. In addition, the Program would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. In short, the Program does not have incremental impacts on public services, and **implementation of any of the Program alternatives (individually or in combination) would not result in a significant contribution to any cumulative public services and hazard response impacts** that could result from other projects in the vicinity of the treatment areas.

8.2.10 Environmental Impacts Summary

Table 8-1 is a summary of all of the potential public services and hazard response impacts associated with the Program alternatives. The number of each statement correlates to its number in the text, and the significance determination symbols are provided at the end. All of the impact determinations are "no impact"; therefore, no mitigation is required.

Table 8-1 Summary of Public Services and Hazard Response Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Effects on Public Services and Hazard Response						
Impact PSH-1: Surveillance activities would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.	N	na	na	na	na	na
Impact PSH-2: Surveillance activities would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.	N	na	na	na	na	na
Impact PSH-3: Surveillance activities would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.	N	na	na	na	na	na
Impact PSH-4: Physical control activities would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.	na	N	na	na	na	na
Impact PSH-5: Physical control activities do not include the use of pesticides or herbicides; therefore, these activities would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.	na	N	na	na	na	na
Impact PSH-6: Physical control activities would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.	na	N	na	na	na	na
Impact PSH-7: Vegetation management activities would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.	na	na	N	na	na	na

Table 8-1 Summary of Public Services and Hazard Response Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact PSH-8: Vegetation management activities would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.	na	na	N	na	na	na
Impact PSH-9: Vegetation management activities would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.	na	na	N	na	na	na
Impact PSH-10: Biological control activities would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.	na	na	na	N	na	na
Impact PSH-11: Biological control activities would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.	na	na	na	N	na	na
Impact PSH-12: Biological control activities would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.	na	na	na	N	na	na
Impact PSH-13: Chemical control activities would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.	na	na	na	na	N	na

Table 8-1 Summary of Public Services and Hazard Response Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact PSH-14: Chemical control ground larviciding and adulticiding activities for mosquitoes would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.	na	na	na	na	N	na
Impact PSH-15: Chemical control ground larviciding and adulticiding activities would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.	na	na	na	na	N	na
Impact PSH-16: Chemical control (aerial application) activities would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.	na	na	na	na	N	na
Impact PSH-17: Chemical control (aerial application) activities would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.	na	na	na	na	N	na
Impact PSH-18: Chemical control (aerial application) activities would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.	na	na	na	na	N	na
Impact PSH-19: Chemical control for yellow jackets and ticks would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.	na	na	na	na	N	na

Table 8-1 Summary of Public Services and Hazard Response Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact PSH-20: Chemical control of yellow jackets and ticks would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.	na	na	na	na	N	na
Impact PSH-21: Chemical control of yellow jackets and ticks would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.	na	na	na	na	N	na
Impact PSH-22: Other Nonchemical Control/Trapping Alternative activities would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.	na	na	na	na	na	N
Impact PSH-23: The Other Nonchemical Control/Trapping Alternative would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.	na	na	na	na	na	N
Impact PSH-24: The Other Nonchemical Control/Trapping Alternative would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.	na	na	na	na	na	N

LS = Less-than-significant impact
N = No impact
na = Not applicable
SM = Potentially significant but mitigable impact
SU = Significant and unavoidable impact

8.2.11 Mitigation and Monitoring

No impacts would occur as a result of any of the Program alternatives, and no mitigation is required for ensuring an adequate public services and hazard response. Therefore, no monitoring of mitigation measures is needed.

9 Water Resources

Chapter 9 evaluates potential impacts of the Marin/Sonoma Mosquito and Vector Control District's (MSMVCD or District) Integrated Vector Management Plan (IVMP) implementation on water resources. Results of the evaluation are provided at the programmatic level. Section 9.1, Environmental Setting, presents an overview of the physical properties and environmental settings; and contains federal regulations, state regulations, and local ordinances and regulations that are applicable to the Program. Section 9.2, Environmental Impacts and Mitigation Measures, presents the following:

> Environmental concerns and evaluation criteria: A determination of whether the Program alternatives would cause any potentially significant impacts to regional hydrologic resources

> Discussion of methods and assumptions, including findings from the Ecological and Human Health Risk Assessment, which is included as Appendix B

> Discussion of potential impacts of the Program alternatives, and recommendations for mitigation, if required, for those impacts

> Cumulative impacts summary

> A summary of environmental impacts to hydrologic resources

9.1 Environmental Setting

9.1.1 California's Hydrologic and Geomorphic Regions

The hydrologic resources of California can be divided into regions based on several hydrologic characteristics. The California Water Plan divides California into 10 hydrologic regions. These regions are delineated based upon the state's major drainage basins. Each region has distinct precipitation characteristics and waterbodies.

Hydrologic regions over the District Program Area include portions of the North Coast and San Francisco Bay regions. The Program Area also overlaps a small portion of the Sacramento River hydrologic region. The District's Service Area (Marin and Sonoma Counties) and lands in adjacent counties (Lake, Mendocino, Napa, and Solano Counties) comprise the District's Program Area, and the hydrologic regions with important water features for the District are shown on Figure 9-1. Description of surface and groundwater characteristics for the differing hydrologic regions relied on *California Water Plan, Update 2009* and *California Water Plan, Update 2013, Advisory Committee Review Draft* (CDWR 2009a-c, 2013a-d).

9.1.1.1 San Francisco Bay Hydrologic Region

The San Francisco Bay Hydrologic Region (Bay Region) occupies approximately 4,500 square miles, from Tomales Bay in Marin County to southern Santa Clara County, and inland to the confluence of the Sacramento and San Joaquin Rivers near Collinsville. The eastern boundary follows the crest of the Coast Range where the highest peaks are more than 4,000 feet above mean sea level (CDWR 2013b). This region includes portions of Marin, Sonoma, Napa, Solano, San Mateo, Santa Clara, Contra Costa, and Alameda counties.

Principle watersheds in the Bay Region include Tomales Bay, Corte Madera Creek, Novato Creek, Petaluma River, Sonoma Creek, Napa River, Wildcat Creek, San Pablo Creek, Green Valley Creek, Suisun Creek, Walnut Creek, San Mateo Creek, San Francisquito Creek, Guadalupe River, Coyote Creek, Alameda Creek, San Lorenzo Creek, and San Leandro Creek watersheds. These watersheds drain into Suisun, San Pablo, North San Francisco, and South San Francisco bays, or directly into the

Pacific Ocean. For example, the Guadalupe River and Coyote and Alameda creeks drain from the Coast Range and flow northwest into San Francisco Bay. The Napa River originates in the Mayacamas Mountains at the northern end of Napa Valley and flows south into San Pablo Bay. Sonoma Creek begins in mountains within Sugarloaf State Park and flows south through Sonoma Valley into San Pablo Bay.

A large proportion of the nine counties that surround the San Francisco Bay is urbanized. As a result, many creeks have been confined to underground culverts beneath the developed regions. While many larger creeks remain open, they often have been heavily modified to run in concrete channels to optimize flood conveyance and provide flood protection. Ownership of Bay Area streams is a patchwork of public title, public easements, and private ownership that complicates policies and jurisdiction over, or maintenance responsibility for, urban streams. Many Bay Area stream reaches have, in fact, no established public jurisdiction or maintenance responsibility (RMC 2006).

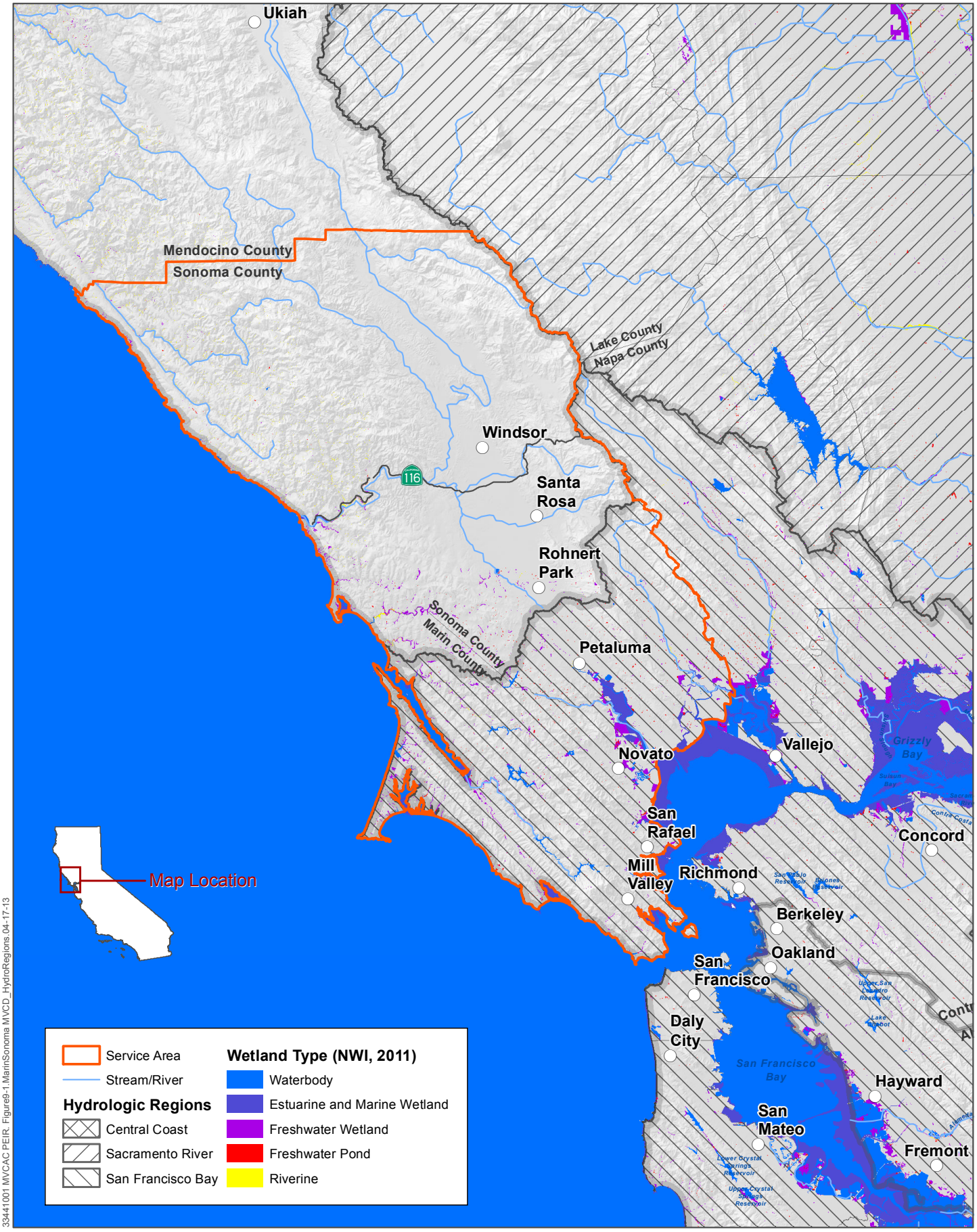
Tidal marshes occur throughout much of the fringe of the San Francisco Bay, from the lowest extent of vascular vegetation to the top of the intertidal zone (at the maximum height of the tides). Tidal marsh also exists in the tidal reaches of local rivers and streams. Tidal marshland was once more extensive and was estimated to be 190,000 acres; however, development in the region has decreased the amount of tidal marshland to approximately 40,000 acres. A large effort has recently been undertaken to restore these ecosystems. High-quality wetlands have been shown to moderate the effect of floods, improve water quality, help maintain shipping channels, and provide habitat to numerous species (Goals Project 1999).

Like most of Northern California, the climate in the Bay Region largely is governed by weather patterns originating in the Pacific Ocean. About 90 percent of the annual precipitation falls between November and April. The North Bay receives about 20 to 25 inches of precipitation annually. In the South Bay, east of the Santa Cruz Mountains, annual precipitation is only about 15 to 20 inches because of the rain shadow effect. Temperatures in the Bay Region generally are cool, and fog often resides along the coast. The inland valleys receive warmer, Mediterranean-like weather (average summer high temperatures are about 80 degrees Fahrenheit). The gap in the rolling hills at Carquinez Strait allows cool air to flow from the Pacific Ocean into the Sacramento Valley. Most of the interior North Bay and the northern parts of the South Bay are influenced by this marine effect. By contrast, the southern interior portions of the South Bay experience very little marine air movement (CDWR 2013b).

Land use in the Bay Region is diverse. Residents live in urban, suburban, and rural areas. Some of these areas are on natural floodplains, which historically were used for agriculture. Agriculture accounts for 21 percent of the Bay Region's land area, most of which is in the North and Northeast Bay in Napa, Marin, Sonoma, and Solano counties. Santa Clara and Alameda counties also have significant agricultural acreage at the edge of urban development (CDWR 2013b).

The region has many significant water management challenges: sustaining water supply, water quality, and the ecosystems in and around San Francisco Bay; reducing flood damages and adapting to impacts from climate change. Numerous government agencies and water districts deliver, treat, and regulate water in the Bay Region. Many planning organizations identify present and future challenges in the region such as land use, housing, environmental quality, economic development, wetlands, water quality, water reliability, stormwater management, flood protection, watershed management, groundwater management, fisheries, and ecosystem restoration (CDWR 2013b).

Groundwater basins underlie approximately 1,400 square miles or 30 percent of the Bay Region and account for about 15 percent of the region's average annual water supply. The Bay Region has 25 identified groundwater basins, as shown on Figure SFB-3 (CDWR 2013b) The Santa Clara Valley, Livermore Valley, Westside, Niles Cone, Napa-Sonoma Valley, and Petaluma Valley are heavily used groundwater basins (CDWR 2013b).



33441001 MVCAC PEIR Figure9-1 MarinSonoma MVCD_HydroRegions.04-17-13

Source: Cardno ENTRIX, 2013

INTEGRATED VECTOR MANAGEMENT PROGRAM PEIR

Marin/Sonoma Mosquito & Vector Control District

Figure 9-1 - Program Area and California Hydrologic Regions with Major Water Bodies

Ongoing surface water quality issues exist in the Bay Region. Pollutants from urban and rural runoff include pathogens, nutrients, sediments, and toxic residues. Some toxic residues are from past human activities such as mining; industrial production; and the manufacture, distribution, and use of agricultural pesticides. These residues include mercury, polychlorinated biphenyls, selenium, and chlorinated pesticides. Emerging pollutants in the region include flame retardants and pharmaceuticals.

San Francisco Bay and a number of the streams, lakes, and reservoirs in the Bay Region have elevated mercury levels, as indicated by elevated mercury levels in fish tissue. The major source of the mercury is historic mercury mining and mining activities in the Sierra Nevada and coastal mountains. Large amounts of contaminated sediments were discharged into the Bay from Central Valley streams and local mines in the Bay Area. Significant impaired waterbodies include the Bay, the Guadalupe River in Santa Clara County (from New Almaden Mine discharges), and Walker Creek in Marin County (from Gambonini Mine discharges). The SFBRWQCB has adopted total maximum daily loads (TMDLs) for mercury in the Bay, Guadalupe River, and Walker Creek (CDWR 2013b).

Water agencies in the region have relied on importing water from the Sierra Nevada for nearly a century to supply their customers. Water from the Mokelumne and Tuolumne rivers accounts for about 38 percent of the region's average annual water supply. Water from the Delta via the federal Central Valley Project and the State Water Project accounts for another 28 percent. Approximately 31 percent of the average annual water supply is from local groundwater and surface water, and 3 percent is from miscellaneous sources. Population growth and concerns over diminishing water quality have led to the development of local surface water supplies, recharge of groundwater basins, and incorporation of conservation guidelines (CDWR 2013b).

Drinking water in the Bay Region ranges from high-quality Mokelumne and Tuolumne river water to variable-quality Delta water, which constitutes about one-third of the domestic water supply. Purveyors that depend on the Delta for all or part of their domestic water supply can meet drinking water standards, but still need to be concerned about microbial contamination, salinity, and organic carbon.

The Bay Region generally receives very little snow, so floodwaters originate primarily from intense rainstorms. The northern portion of the region receives more precipitation and floods more often than the southern portion. Flooding occurs more frequently in winter and spring and can be intense with a short duration in small watersheds with steep terrain. Local flooding tends to occur when large, widespread storms fall on previously saturated watersheds that drain into local valleys. The greatest flood damages occur in the lower reaches of streams when floodwaters spill onto the floodplain and spread through urban neighborhoods (CDWR 2013b).

Drought, overdraft, and pollution have impaired portions of 28 groundwater basins in the Bay Region. The basins face a perpetual threat of contamination from spills, leaks, and discharges of solvents, fuels, and other pollutants. Contamination affects the supply of potable water and water for other beneficial uses. Some municipal, domestic, industrial, and agricultural supply wells have been removed from service due to the presence of pollution, mainly in shallow groundwater zones. Overdraft can result in land subsidence and saltwater intrusion, although active groundwater management has stopped or reversed the saltwater intrusion (CDWR 2013b).

A variety of historical and ongoing industrial, urban, and agricultural activities and their associated discharges have degraded groundwater quality, including industrial and agricultural chemical spills, underground and aboveground tank and sump leaks, landfill leachate, septic tank failures, and chemical seepage via shallow drainage wells and abandoned wells. The region has over 800 groundwater cleanup cases, about half of which are related fuel spills from leaking underground tanks. In many cases, the groundwater is treated and discharged to surface waters via storm drains (CDWR 2013b).

9.1.1.2 North Coast Hydrologic Region

The North Coast Hydrologic Region (North Coast region) encompasses all basins draining into the Pacific Ocean from the Oregon state line to Tomales Bay in Marin County. This region includes coastal areas, redwood forests, inland mountain valleys, and semidesert-like areas. The southern tip of this region includes a portion of Sonoma and Marin counties. Watersheds within Sonoma and Marin counties include Gualala River, Russian River, and Bodega; characteristics of these watersheds are described at the end of this section.

In the North Coast region, topographic relief can be steep and precipitation is generally high relative to the rest of the state. Heavy rainfall over the mountainous portions of the North Coast region (up to 100 inches per year) makes it California's most water-abundant area. The western coastal portion of this region receives less rainfall (e.g., at Bodega Bay in Sonoma County, annual precipitation is about 37 inches). Average temperatures are moderated by the influence of the Pacific Ocean and range from highs in the mid-80s in the summer to lows in the mid-30s during the winter (CDWR 2013c).

The North Coast region is generally forest land with agricultural land concentrated in narrow river valleys. Land use issues in the region include activities causing soil erosion such as road construction, logging and hillside agriculture (vineyards), which can affect native fish spawning. Many of the region's watersheds support threatened and endangered species of plants and animals, and many North Coast streams and rivers support runs of salmon and steelhead trout. Forest management practices are also a significant issue impacting flood management.

The North Coast region contains water service providers of all types, from small, private facilities that provide water for just a few neighboring residences to large municipal suppliers and wastewater treatment facilities. Private water districts include those representing counties or portions of counties, municipalities, irrigation districts, or particular waterbodies. Many of the smaller communities and rural areas in the North Coast region are generally supplied by small local surface and groundwater systems. In general, for the North Coast region, groundwater contamination from leaking underground tanks and health and safety issues from contaminated areas that are open to the public are identified by the California Department of Water Resources as priority issues related to groundwater quality (CDWR 2009c). Additionally, groundwater quality problems in the North Coast region include contamination from seawater intrusion and nitrates in some shallow coastal groundwater aquifers, and iron, boron, and manganese in some of the inland groundwater basins of Sonoma County (CDWR 2009c).

One of the largest water supply reservoirs in the North Coast region includes USACE's 380,000 acre-foot Lake Sonoma in the Russian River watershed. Lake Sonoma is operated to provide flood control and instream flows in the Lower Russian River in Sonoma County. This facility provides water for instream flows, recreation, hydropower, and water supply purposes (CDWR 2013c).

9.1.1.2.1 Southern Watersheds

The Gualala River watershed encompasses about 300 square miles; the Gualala River flows from Mendocino County to Sonoma County in a north-south direction, reaching the ocean at the town of Gualala. The watershed contains mostly mountainous terrain where tributaries flow through steep valleys with narrow floors that contain erodible soil. Most of the annual precipitation occurs between October and April, with the greatest amounts in January. Rainfall averages about 38 inches per year at the coast and up to 100 inches per year on the inland peaks. Timber companies own about one-third of the watershed. Orchards and ranching are on the decline while the watershed has seen an increase in hillside vineyard development. The watershed supports an anadromous fishery that includes Coho salmon. The Gualala River provides the primary source of drinking water for Sea Ranch and Gualala (CDWR 2013c).

The Russian River watershed encompasses 1,485 square miles in Mendocino and Sonoma counties. It is bounded by the Coast Ranges on both the east and west. The mainstem is about 110 miles long and flows from north of Ukiah southward through Redwood Valley (Mendocino County) to its confluence with

Mark West Creek, where it turns west, passes through the coast range, and empties into the Pacific Ocean. The summer climate is moist and cool near the coast with temperatures increasing in the valley areas, which are isolated from the cooling coastal influence. During winter, average rainfall ranges from 30 to 80 inches, depending on locale. The Russian River watershed is primarily an agricultural area with the greatest emphasis on vineyard and orchard crops. Besides agriculture, a growing trend toward light industry and commercial development and a significant telecommunications industry are noticeable within the region (CDWR 2013c).

The Bodega watershed contains streams with headwaters in the Coast Range entering the Pacific Ocean south of the Russian River. Salmon, Americano, and Stemple creeks and their associated estuaries are the main waterbodies in this watershed. The terrain is relatively steep and erodible and is sensitive to disturbance. Cooler temperatures and relatively high winter rainfall due to coastal influences typify the climate of the Bodega watershed. Because of the Mediterranean climate, summertime flows are often nonexistent in Americano and Stemple creeks, while Salmon Creek flow is low but sustained. Each of these watersheds has estuary areas (CDWR 2013c).

9.1.1.3 Existing Water Quality

Statewide and regional surface water monitoring has identified pesticides in surface waters and sediments throughout the Program Area and vicinity. A query of water quality data available through the California Environmental Data Exchange Network (CEDEN) water quality database revealed detectable quantities of several chemicals that the District will use and several additional chemicals of the same class (i.e., pyrethroids). See Tables 2-1 through 2-5 for a list of all chemicals the District uses or proposes to use.

The following is a summary of CEDEN data from 1993 to 2012 regarding the concentrations of these chemical constituents when detected and the waterbodies in which they were discovered (CEDEN 2013). In addition to the CEDEN data, the list below includes Water Year 2012 Regional Monitoring Coalition pesticide results (BASMAA 2013). The Regional Monitoring Coalition was formed to implement the monitoring program required by the Municipal Regional Stormwater NPDES Permit (Order R2-2009-0074) issued by the SFBRWQCB. In consideration of their more frequent usage and potentially greater toxicity compared with other commonly applied pesticides used in this geographic region, monitoring of the class of pesticides known as pyrethroids was conducted by the Regional Monitoring Coalition to explore potential causes of toxicity to *Hyalella azteca* in sediments. Based on monitoring results, BASMAA (2013) concluded that it is likely that pyrethroids caused toxicity in water year 2012.

> Allethrin was detected in sediments of various bays in the region including Central Bay, Grizzly Bay, San Pablo Bay (Pinole Point), San Francisco Bay (Yerba Buena Island), and Suisun Bay. Concentrations ranged from 0.238 to 5.61 micrograms per kilogram (µg/kg) in these bay sediments. Allethrin concentrations within Sacramento River and San Joaquin River sediments ranged from 0.33 to 2.13 µg/kg.

> Esfenvalerate/fenvalerate were detected in Central Bay, Grizzly Bay, and Lower South Bay sediments in concentrations ranging from 0.163 to 0.577 µg/kg. Tembladero Slough sediments also contained esfenvalerate/fenvalerate concentrations of up to 60.8 µg/kg.

> The concentration of all permethrin isomers detected in the water column of the Hayward Industrial Storm Drain ranged from 1.57 to 285 nanograms per liter (ng/L). Sunnyvale East Channel, Guadalupe River, and Lower Marsh Creek sediments contained concentrations ranging from 3.81 to 20.9 µg/kg. Cis- and trans-permethrin isomers were detected in Central Bay, Grizzly Bay, Lower South Bay, San Pablo Bay (Pinole Point), South Bay, and Suisun Bay sediments in concentrations ranging from 0.10 to 1.32 µg/kg. Cis- and trans- isomers were also detected in Coyote Creek, Redwood Creek, San Leandro Creek, and Tembladero Slough sediments in concentrations 0.12 to 25.6 µg/kg. Only the cis- isomer of permethrin was detected in Guadalupe Creek, Laurel Creek, Salinas River, and San Mateo Creek sediments in concentrations ranging from 3.22 to 11.1 µg/kg. Trans-permethrin was the

only isomer detected in Lagunitas Creek and the Pajaro River sediments in concentrations ranging from 4.06 to 4.52 µg/kg.

> Phenothrin was detected in Central Bay and San Francisco Bay (Yerba Buena Island) sediments in concentrations ranging from 0.988 to 4.81 µg/kg.

Additional queries were made to the USEPA's ECOTOX database to compare regional water quality data to available ecological toxicity data (see Table 9-1). The toxicology data are expressed in LC50. The LC50 value is used as a standard measure of toxicity for evaluation and comparison of chemicals. LC50 refers to the lethal concentration of a chemical (amount of chemical in a volume of food, water, or air) that that would kill 50 percent of a group of test animals exposed to the chemical for a defined exposure time. Chemicals with lower LC50 values are more toxic. The LC50 values in Table 9-1 are populated from the lowest available constituent concentrations in which a 50 percent die-off for the test species is observed (USEPA 2013). LC50 values are not available for sediment. Freshwater and saltwater values are provided where available.

A 2010 study performed by the CDPR analyzed the presence of pyrethroid insecticides in California's surface waters from urban areas. The most frequently detected pyrethroids were bifenthrin followed by permethrin and cyfluthrin. These pyrethroids are found in many common household insecticides. Bifenthrin and cyfluthrin, which the District does not use, were detected with the highest concentrations in both water and sediment. Detected concentrations of bifenthrin and cyfluthrin exceeded the acute toxicity benchmarks for fish and for aquatic invertebrates in more than 8 and 12 percent of the water samples, respectively (CDPR 2010b).

Table 9-1 Pesticide Concentrations in Surface Water and Sediment throughout the Program Area and Vicinity (1993 to 2012)

	Sediment		Water			
Pesticide	**Concentration (µg/kg)**	**LC50 (µg/kg)**	**Concentration (ng/L)**	**LC50 (ng/L)**	**Standard Test Species**	**Exposure Time**
Allethrin	0.238 - 5.61	*	NA	1,800	Coho Salmon (*Oncorhynchus kisutch*)	96-hour exposure in Freshwater Medium
Permethrin	3.81 - 20.9	*	1.57 - 285	2	Channel Catfish (*Ictalurus punctatus*)	96-hour exposure in Freshwater Medium
				4	Amphipod (*Eohaustorius estuarius*)	48-hour exposure in Saltwater Medium
Cis- and Trans-Permethrin Isomers	0.10 - 25.6	*	*	465	Water Flea (*Ceriodaphnia dubia)*	96-hour exposure to Cis-Permethrin in Freshwater Medium
Phenothrin	0.988 - 4.81	*	*	140	Rainbow Trout (*Oncorhynchus mykiss*)	96-hour exposure in Freshwater Medium
				21	Opossum Shrimp (*Americamysis bahia)*	96-hour exposure in Saltwater Medium

*No Data Available

9.1.2 Regulatory Setting

The Program includes activities under the jurisdiction of federal, state, and local agencies. Applicable regulations are summarized below and include aspects related to both surface water and groundwater. The primary focus of this regulatory summary is the water quality aspects related to the Program alternatives. Because the Program will not cause changes to natural precipitation patterns, runoff, or groundwater infiltration, changes to water quantity are not anticipated.

9.1.2.1 Federal

9.1.2.1.1 Federal Clean Water Act (33 USC Section 1251 et seq.)

The USEPA is the federal agency responsible for water quality management and administers the federal Water Pollution Control Act Amendments of 1972 and 1987, collectively known as the Clean Water Act (CWA). The CWA establishes the principal federal statutes for water quality protection. It was established with the intent "to restore and maintain the chemical, physical, and biological integrity of the nation's water, to achieve a level of water quality which provides for recreation in and on the water, and for the propagation of fish and wildlife." Several key CWA sections guide the regulation of water pollution in the US:

> Section 208, Water Quality Control Plans. This section requires the preparation of local water quality control plans throughout the nation. Each water quality control plan covers a defined drainage area. The primary goal of each water quality control plan is to attain water quality standards established by the CWA and the state governments within the defined area of coverage. Minimum content requirements, preparation procedures, time constraints, and federal grant funding criteria pertaining to the water quality control plans are established in Section 208. The USEPA has delegated preparation of the water quality control plans to the individual states. More information is provided below in the state regulatory setting section.

> Section 303(d) Water Quality Limited Surface Waters. This section requires each state to provide a list of impaired waters that do not meet or are expected not to meet state water quality standards as defined by that section. It also requires the state to develop TMDLs from the pollution sources for such impaired waterbodies. Novato Creek, Miller Creek, Gallinas Creek, San Rafael Creek, Corte Madera Creek, Arroyo Corte Madera Del Presidio, and Coyote Creek, located in Marin County, and Calabazas Creek, Petaluma River, and San Antonio Creek, located in Sonoma County, are listed as impaired for diazinon. Water quality degradation of these urban creeks by diazinon is addressed by a completed and approved TMDL program. See the state regulatory setting section (Section 9.1.2.2) for description of the Diazinon and Pesticide-Related Toxicity in Urban Creeks TMDL. San Pablo Bay and Central San Francisco Bay are downstream waterbodies that are listed for chlordane, dieldrin, and dichlorodiphenyltrichloroethane (DDT), which are persistent organochlorine pesticides and legacy pollutants. Note that the District is not proposing to use diazinon or any of these pesticides.

> Section 401, Water Quality Certifications. This CWA section requires that, prior to the issuance of a federal license or permit for an activity or activities that may result in a discharge of pollutants into waters of the US (see Section 404 discussion, below), the permit applicant must obtain a certification from the state in which the discharge would originate. A state certification indicates that the proposed activity or activities would not result in a violation of applicable water quality standards established by federal or state law, or that no water quality standards apply to the proposed activity. The SWRCB and/or the nine RWQCBs administer the certification program in California.

> Section 402, NPDES. The NPDES requires permits for pollution discharges (except dredge or fill material) into waters of the US, such that the permitted discharge does not cause a violation of federal and state water quality standards. Biological and residual pesticides discharged into surface waters constitute pollutants within the meaning of the CWA and require coverage under an NPDES permit. NPDES permits define quantitative and/or qualitative pollution limitations for the permitted source and control measures that must be implemented to achieve the pollution limitations. Pollution control

measures are often referred to as BMPs. In California, NPDES permits are issued by the SWRCB or the RWQCBs.

> Section 404, Discharge of Dredge and Fill Material. Section 404 assigns the USACE with permitting authority for proposed discharges of dredged and fill material into waters of the US, defined as "…waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide; territorial seas and tributaries to such waters." The USACE typically considers all natural drainages with defined beds and banks to be waters of the US. Section 404 establishes procedures by which the permitting agency is to review, condition, approve, and deny permit requests. Per the regulations, permitting agencies are responsible to conduct public noticing and provide the opportunity for public hearings during the review of each permit request. This responsibility includes informing the USFWS and/or NMFS of each permit request. Consultation with the USFWS and/or NMFS is required for proposed discharges that could affect species protected by the federal Endangered Species Act. Measures that are required by the USFWS and/or NMFS to minimize impacts to federally protected species must be included as conditions of the permit. The USACE also authorizes, with limited application requirements and associated delay, certain activities with minimal adverse effects on the environment, under nationwide permits. Currently, 50 nationwide permits exist, of which about half require preconstruction notification, which USACE reviews to verify the activity qualifies for the nationwide permit.

9.1.2.1.2 Federal Insecticide, Fungicide, and Rodenticide Act

The FIFRA was first passed in 1947 to establish labeling provisions and procedures for registering pesticides with the USDA. It was rewritten in 1972 and has since been amended several times. In its current form, FIFRA mandates that USEPA regulate the use and sale of pesticides to protect human health and preserve the environment. Registration with the USEPA assures that pesticides will be properly labeled and that, if used in accordance with specifications, they will not cause unreasonable harm to the environment. Pesticide use in California is also regulated by the CDPR and local County Agricultural Commissioners.

9.1.2.1.3 California Toxics Rule

The USEPA has developed water quality criteria for priority toxic pollutants and other provisions for water quality standards to be applied to inland surface waters, enclosed bays, and estuaries in California. This rule was developed to address a gap in California's water quality standards that was created when the state's water quality control plans containing water quality criteria for priority toxic pollutants were overturned in 1994. The established numerical standards were deemed necessary to protect human health and the environment. The rule includes ambient aquatic life criteria for 23 priority toxic pollutants, ambient human health criteria for 57 priority toxics, and a compliance schedule.

9.1.2.1.4 Safe Drinking Water Act of 1974

The federal Safe Drinking Water Act of 1974 is the main federal law that regulates drinking water quality. This act authorizes the USEPA to set national health-based standards for drinking water to protect against both naturally occurring and man-made contaminants that may be found in drinking water. With the passage of the federal Safe Drinking Water Act of 1974, the USEPA established and enforced mandatory nationwide minimum standards. California adopted its own Safe Drinking Water Act in 1976 that gave California Department of Health Services (now CDPH) responsibility for the administration of the federal Safe Drinking Water Act in California. Under this program, the USEPA has delegated primary responsibility for setting and enforcing drinking water standards to the CDPH.

9.1.2.1.5 Rivers and Harbors Act

The Rivers and Harbors Act (RHA) of 1899 prohibits the unauthorized alteration or obstruction of any navigable waters of the US. As defined by the RHA, navigable waters include all waters that are:

> Historically, presently, or potentially used for interstate or foreign commerce

> Subject to the ebb and flow of tides

Regulations implementing RHA Section 10 are coordinated with regulations implementing CWA Section 404. The RHA specifically regulates:

> Construction of structures in, under, or over navigable waters

> Deposition or excavation of material in navigable waters

> All work affecting the location, condition, course, or capacity of navigable waters

The USACE administers the RHA. If a proposed activity falls under the authority of RHA Section 10 and CWA Section 404, the USACE processes and issues a single permit. For activities regulated only under RHA Section 10, such as installation of a structure not requiring fill, permit conditions may be added to protect water quality during construction.

Program activities are not anticipated to affect any facilities that would be regulated under the RHA.

9.1.2.2 State

9.1.2.2.1 Porter-Cologne Act

The Porter-Cologne Act (California Water Code Section 13000) is the principal law governing water quality regulation in California. It establishes a comprehensive program to protect water quality and the beneficial uses of water. The Porter-Cologne Act applies to surface waters, wetlands, and groundwater, and to both point and nonpoint sources of pollution. Pursuant to the Porter-Cologne Act, it is the policy of the State of California that:

> The quality of all the waters of the state shall be protected.

> All activities and factors affecting the quality of water shall be regulated to attain the highest water quality within reason.

> The state must be prepared to exercise its full power and jurisdiction to protect the quality of water in the state from degradation.

Pursuant to the Porter-Cologne Act, the responsibility for protection of water quality in California rests with the SWRCB. The SWRCB administers federal and state water quality regulations for California's ocean waters and also oversees and funds the state's nine RWQCBs. The RWQCBs prepare water quality control plans, establish water quality objectives, and carry out federal and state water quality regulations and permitting duties for inland waterbodies, enclosed bays, and estuaries within their respective regions. The Porter-Cologne Act gives the SWRCB and RWQCBs broad powers to protect water quality by regulating waste discharge to water and land and by requiring cleanup of hazardous wastes.

9.1.2.2.2 State Antidegradation Policy

The SWRCB adopted the Statement of Policy with Respect to Maintaining High Quality Water in California (Resolution No. 68-16) on October 28, 1968. This policy is generally referred to as the "Antidegradation Policy" and protects surface water and groundwater where existing water quality is higher than the standards set by the Water Quality Control Plan (or Basin Plan) to protect beneficial use of the waters. Under the Antidegradation Policy, any action that can adversely affect water quality in surface water or groundwater:

> Must be consistent with the maximum benefit to the people of the state.

> Must not unreasonably affect present and anticipated beneficial use of such water.

> Must not result in water quality less than that prescribed in water quality plans and policies.

9.1.2.2.3 Safe Drinking Water Act 1976

California adopted its own Safe Drinking Water Act in 1976 that gave California Department of Health Services the responsibility for the administration of the federal Safe Drinking Water Act in California. This responsibility was then moved to the CDPH. The first approach is to safeguard public welfare by limiting the level of specific contaminants that can impact public health. These limits are identified as Primary MCLs and are specific concentrations that cannot be exceeded for a given constituent. The second approach is a treatment technique that is based on distribution system sampling in comparison to an action level. If the action level is exceeded in more than 10 percent of the samples, then additional treatment is required of the water supplier. Currently, treatment technique limits apply only to copper and lead. CDPH also has established Secondary MCLs that regulate constituents that affect water quality aesthetics (such as taste, odor, or color). Generally, CDPH uses the Secondary MCLs as guidelines.

Another component of the California Safe Drinking Water Act is the requirement of Cal-EPA's Office of Environmental Health Hazard Assessment to develop PHGs for contaminants in California's publicly supplied drinking water. PHGs are concentrations of drinking water contaminants that pose no significant health risk if consumed for a lifetime, based on current risk assessment principles, practices, and methods. This office establishes PHGs pursuant to Health & Safety Code Section 116365 for contaminants with MCLs and for those for which CDPH will be adopting minimum detection limits. Public water systems use PHGs to provide information about drinking water contaminants in their annual Consumer Confidence Reports. Certain public water systems must provide a report to their customers about health risks from a contaminant that exceeds its PHG and about the cost of treatment to meet the PHG, and hold a public hearing on the report.

9.1.2.2.4 Water Quality Control Plan

The Water Quality Control Plans (or Basin Plans) of all nine of the RWQCBs and the California Ocean Plan (prepared and implemented by the SWRCB) collectively constitute the State Water Quality Control Plan. These plans are the RWQCB's master water quality control planning documents. They designate beneficial uses and water quality objectives for waters of the state, including surface waters and groundwater, and also include programs of implementation to achieve water quality objectives. According to the requirements of the CWA and the California Porter-Cologne Act, each Basin Plan has been designed to support the intentions of the CWA and the Porter-Cologne Act by (1) characterizing the water resources within a region, (2) identifying beneficial uses that exist or have the potential to exist in each waterbody, (3) establishing water quality objectives for each waterbody to protect beneficial uses or allow their restoration, and (4) providing an implementation program that achieves water quality objectives. Implementation program measures include monitoring, permitting, and enforcement activities. The Basin Plans include numeric site-specific water quality objectives and narrative objectives for toxicity, chemical constituents, and tastes and odors. The narrative toxicity objective states: "*All waters shall be maintained free of toxic substances in concentrations that produce detrimental physiological responses in human, plant, animal, or aquatic life*."

9.1.2.2.5 Diazinon and Pesticide-Related Toxicity in Urban Creeks TMDL

Resolution R2-2005-0063 amended the Basin Plan for the San Francisco Bay region to establish a Water Quality Attainment Strategy and TMDL for diazinon and pesticide-related toxicity in the Bay Area region creeks. As diazinon use was phased out in 2004, alternatives began to pose water quality concerns and pyrethroids in particular were identified as the likely cause of sediment toxicity in some Bay Area urban creeks. To account for pesticide use changes over time, the Basin Plan amendment includes generic

pesticide-related toxicity targets to comply with the narrative toxicity objective. When pesticide-related toxicity occurs in urban creek water, creeks do not meet the narrative toxicity objective as stated above in *Water Quality Control Plan*. When pesticide-related toxicity occurs in sediment, the creeks also do not meet the narrative sediment objective, which states: "Controllable water quality factors shall not cause a detrimental increase in the concentrations of toxic pollutants in sediments or aquatic life." Management actions designed to reduce the impacts of pesticide-related toxicity are outlined within the TMDL and Water Quality Attainment Strategy and are currently underway via Provision C.9 of the Municipal Regional NPDES Permit (BASMAA 2013).

9.1.2.2.6 California Pesticide Regulatory Program

CDPR regulates the sale and use of pesticides in California. CDPR is responsible for reviewing the toxic effects of pesticide formulations and determining whether a pesticide is suitable for use in California through a registration process. Although CDPR cannot require manufacturers to make changes in labels, it can refuse to register products in California unless manufacturers address unmitigated hazards by amending the pesticide label. Consequently, many pesticide labels that are already approved by USEPA also contain California-specific requirements. Pesticide labels are application requirements and include instructions informing users how to make sure the product is applied only to target pests including precautions the applicator should take to protect human health and the environment. For example, product labels may contain such measures as restrictions in applications to certain land uses and weather (i.e., wind speed) parameters.

9.1.2.2.7 Cooperative Agreement between the California Department of Public Health and Local Vector Control Agencies

Due to their public health mission, CDPR's Pesticide Regulatory Program provides special procedures for vector control agencies that operate under a Cooperative Agreement with CDPH. The application of pesticides by vector control agencies is regulated by a special and unique arrangement among the CDPH, CDPR, and County Agricultural Commissioners. CDPR does not directly regulate vector control agencies. CDPH provides regulatory oversight for vector control agencies that are signatory to the Cooperative Agreement. Signatories to the agreement use only pesticides listed by CDPH, maintain pesticide use reports, and ensure that pesticide use does not result in harmful residues on agricultural products. Both CDPH and County Agricultural Commissioners inspect District facilities, training and safety practices documents, staff certifications, continuing education compliance records, and equipment. County Agricultural Commissioners also conduct unannounced field inspections of staff and equipment to document compliance with product label requirements, as well as other regulations and safety practices.

9.1.2.2.8 Pesticide Permits

In response to a Sixth Circuit Court decision in 2009 that the application of pesticides at, near, or over waters of the US that results in discharges of pollutants requires coverage under a NPDES permit, the SWRCB adopted four Pesticide Permits. The following two are applicable to the Program. The Spray Applications Permit is also relevant to the regulatory setting when the District performs pesticide applications for the CDFA and/or USFS.

> Statewide NPDES Vector Control Permit. The Statewide NPDES Permit for Biological and Residual Pesticide Discharges to waters of the US from Vector Control Applications (SWRCB Water Quality Order No. 2011-0002-DWQ with amendments; NPDES No. CAG 990004; Vector Control Permit) covers the point source discharge of biological and residual pesticides resulting from direct and spray applications for vector control. The District completed application requirements, including preparation of a Pesticide Application Plan (PAP) and public notice requirements, and received permit approval on October 31, 2011. Permitted larvicide active ingredients include monomolecular films, methoprene, *Bacillus thuringiensis* subspecies *israelensis* or Bti, *Bacillus sphaericus* or Bs, temephos, petroleum distillates, and spinosad. Permitted adulticide active ingredients include malathion, naled, pyrethrin,

deltamethrin, lambda-cyhalothrin, permethrin, resmethrin, sumithrin, prallethrin, the synergist PBO, etofenprox, and N-octyl bicycloheptene dicarboximide (MGK-264). The permit also includes language that allows adulticides and larvicides that are newly registered in California and that are based on active ingredients currently registered by CDPR to be used for vector control without having to further amend the permit. The permit contains a receiving water limitation for malathion and receiving water monitoring triggers for the other active ingredients. To obtain coverage under the permit, each discharger (typically a vector control district) must submit a Notice of Intent, application fee, and PAP, which is subject to approval by the SWRCB following a 30-day public comment period.

The PAP serves as a comprehensive plan developed by the discharger that describes the project, the need for the project, what will be done to reduce water quality impacts, and how those impacts will be monitored. The PAP must include a description of application and target areas, evaluation of available BMPs, and description of BMPs to be implemented. The PAP must include a discussion of the factors influencing the decision to select pesticide applications for vector control, what pesticide products or types expected to be used, and any known degradation by-products. The PAP also includes the methodology used to determine how much pesticide is needed and how this amount was determined, the methods in which pesticides are to be applied, and any adjuvants or surfactants that will be used.

Permittees must comply with the Vector Control Permit Monitoring and Reporting Program (MRP). Visual monitoring may be required during and after pesticide applications, when safe and feasible, to visually assess the area in and around where pesticides are applied for possible and observable adverse incidents. Monitoring of application rates is also required. Adverse incidents must be reported to the RWQCB within 24 hours of identification. Within 30 days a written report must be submitted, which includes a description of actions to be taken to prevent recurrence of adverse incidents. The District submits annual reports that include a description of the type of pesticide used, the quantity used, the location of where the pesticide is used, submittal of documentation such as the Pesticide Application Logs, and review of their PAP.

> Statewide NPDES Aquatic Weed Control Permit. The Statewide General NPDES Permit for Residual Aquatic Pesticide Discharges to Waters of the US from Algae and Aquatic Weed Control Applications (SWRCB Water Quality Order No. 2013-0002-DWQ with amendments; NPDES No. CAG 990005; Aquatic Weed Control Permit) addresses the discharge of residues resulting from pesticide applications using products containing 2,4-D, acrolein, copper, diquat, endothall, fluridone, glyphosate, imazamox, imazapyr, penoxsulam, sodium carbonate peroxyhydrate, triclopyr-based algicides and aquatic herbicides, and adjuvants containing ingredients represented by nonylphenol. The permit contains receiving water limitations for 2,4-D, acrolein, copper, diquat, endothall, fluridone, glyphosate, nonylphenol, toxicity, and dissolved oxygen. The permit also includes receiving water monitoring triggers for imazapyr and triclopyr triethylamine. To obtain coverage under the permit, a discharger must submit a Notice of Intent, application fee, and a vicinity map to the appropriate RWQCB. Effluent limitations contained in the Aquatic Weed Control Permit require that the discharge of residual algicides and aquatic herbicides meet applicable water quality standards, require implementation of BMPs, and include requirements to develop and implement an APAP.

The APAP must describe appropriate BMPs, including compliance with all pesticide label instructions, and a monitoring plan that meets the requirements of the permit MRP. Monitoring requirements include background, event, and post-event sampling for visual, physical, and chemical constituents for each type of aquatic pesticide used for each type of site (flowing water and nonflowing water). Annual reports must summarize monitoring data and address the effectiveness of the APAP to reduce or prevent the discharge of pollutants associated with aquatic pesticide applications. Other specific requirements of the APAP include a description of the waterbody(ies) or waterbody systems being controlled and a description of what weed(s) are being controlled and why. The APAP also serves as a discussion of control tolerances (i.e., how much growth can occur before action is necessary) and of the factors influencing the decision to use aquatic pesticides in regards to those tolerances (pros and

cons). The types of pesticides and adjuvants that are used and the methodology used to determine the amount of product to be applied are also detailed within an APAP. Finally, the APAP should have a description of application and treatment areas within the system and, if applicable, a list of gates or control structures and their inspection schedule to ensure they are not leaking.

> Statewide NPDES Spray Applications Permit. The Statewide General NPDES Permit for Biological and Residual Pesticide Discharges to Waters of the US from Spray Applications (SWRCB Water Quality Order No. 2011-0004-DWQ; NPDES No. CAG 990007; Spray Applications Permit) addresses spray applications of insecticides and herbicides by CDFA and USFS. Under the permit, CDFA is covered for applications of acetamiprid, aminopyralid, *Bacillus thuringiensis*, subspecies *kurstaki* (*Btk*), carbaryl, chlorsulfuron, clopyralid, cyfluthrin, dinotefuran, glyphosate, imazapyr, imidacloprid, malathion, naled, nuclear polyhedrosis virus (NPV), pheromone, pyrethrins, spinosad A and D, triclopyr butoxyethyl ester (BEE), and triclopyr triethylamine salt (TEA). USFS is covered for applications of biological control agents, which is a subset of the CDFA active ingredients.

  The permit contains a receiving water limitation for malathion and receiving water monitoring triggers for many of the other active ingredients. To obtain coverage under the permit, the discharger must submit a Notice of Intent, application fee, and a project- or program-specific PAP to the SWRCB. The PAP must describe the application area, appropriate BMPs for each pesticide project, an evaluation of possible alternatives to pesticide use, and a monitoring plan. The PAP must also include an Off-Target Drift Management Plan. Monitoring requirements include background and event monitoring for visual, physical, and chemical parameters at frequencies similar to the Vector Control Permit. Annual reports must summarize sampling results and recommend improvements to the monitoring program, BMPs, and PAP.

9.1.2.3 Local

A compilation of local ordinances and regulations (or chapters within which they can be found) for counties within the District's Service Area and two adjacent counties in its Program Area is provided in Table 9-2. The counties are Marin, Napa, Solano, and Sonoma counties.

Table 9-2 List of County General Plan Pesticide and Water Quality Policies

County	Name of Code/Plan	Element Title, Chapter and Section
Marin	Marin Countywide Plan	Natural Systems and Agriculture Element, Policy OS-1.c, WR-2.1, WR-2.a, WR-2.j, WR-2.k, WR-2.n,
Napa	Napa County General Plan	Conservation Element, Chapter 10, Policy CON-2e, Policy CON-2f, CON-26, CON-42, CON-47, CON-49, Recreation and Open Space Policy ROS-3
Solano	Solano County General Plan	Health and Safety Element, HS.I-58
Sonoma	Sonoma County General Plan	Land Use Element, Policy LU-11d, Public Safety Element, Policy PS-4n, Policy PS-4, Water Resources WR-3d

Sources: Marin County 2007; Napa County 2009; Solano County 2008; Sonoma County 2009

9.1.2.3.1 County Agricultural Commissioners

In addition to federal and state oversight, County Agricultural Commissioners in California also regulate the sale and use of pesticides and issue Use Permits for applications of pesticides that are deemed as restricted materials by CDPR. County Agricultural Commissioners collect pesticide use reports from the District and other users of pesticides, investigate incidents and illnesses, and conduct annual inspections. County Agricultural Commissioners also conduct unannounced field inspections of staff and equipment to document compliance with product label requirements, as well as other regulations and safety practices.

9.2 Environmental Impacts and Mitigation Measures

The water resource impacts evaluation is provided below. The evaluation qualitatively and quantitatively compares the Program's potential water resource impacts to the significance criteria presented in Section 9.2.1, Evaluation Concerns and Criteria.

9.2.1 Evaluation Concerns and Criteria

Impacts are considered significant if the Program actions cause concentrations of Program compounds in receiving waterbodies (surface water or groundwater) to exceed established water quality objectives or other applicable water quality standards or promulgated regulations on the local, state, or federal level. Increased concentrations of potential pollutants associated with Program activities within the Program Area would be related to the application of Program materials or implementation of Program activities in the Program Area.

As discussed previously in this PEIR, the Program Area is distributed across the District (and adjacent counties) rather than in a single particular location. The effects on water resources are largely attributable to the post-application movement of those compounds identified for use under the Program alternatives to surface water and/or groundwater. Some Program activities that do not involve applications of compounds could also affect water resources.

Concerns related to water resources issues that were raised during public scoping included the following:

> Consideration of CDPH review and approval of mosquito abatement materials and practices proposed for use on watershed lands

> Integration of "Source Reduction" strategies with Stream Maintenance Program approaches in Water Agency-owned flood control channels. (Sonoma County Water Agency)

> Need for description and quantification of dredge or fill activities and evaluation of their impacts

> Impacts of drift from aerial and ground applications on waterbodies, watersheds, and drinking water supplies

> Concern for spread of invasive weeds, erosion, and sedimentation

> Concern about the use of mosquito larvicides and adulticides in or associated with septic tank (onsite wastewater treatment systems) and the potential to impact surface or groundwater resources

While the first two issues are related to Program implementation and coordination with other agencies (who will receive this PEIR), the last three are related to the Physical Control, Vegetation Management, and Chemical Control Alternatives and are addressed in the environmental impact analyses with one exception. This water resource analysis addresses potential impacts to the quality of surface water and groundwater at a programmatic level and does not quantify dredge and fill activities (which could be addressed in the new USACE permit described in Section 2.8.1.3). Because no large-scale consumptive use of water supply is associated with implementation of the Program alternatives, the potential for an impact to water supply would be related to a physical impact to water quality. Additional discussion of the potential for Program pesticides to result in water quality impacts that could affect nontarget ecological receptors is contained in Section 6.2, Ecological Health Environmental Impacts.

9.2.1.1 Thresholds of Significance

Applicable regulatory and planning standards discussed above can be used to determine appropriate thresholds of significance for this water resource analysis.

The Program activities are evaluated in accordance with the Hydrology and Water Quality Section IX of the CEQA Environmental Checklist Form, Appendix G. Several of the topic areas represented by the questions from the checklist are not affected by the Program activities, as follows:

Would the Program substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (e.g., the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?	No, Program activities would not impact groundwater supplies or groundwater recharge.
Would the Program substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or off site?	No, Program activities would not substantially change or alter drainage amount, timing, or patterns. Drainage channels are maintained to improve water circulation to avoid breeding areas for mosquitoes.
Would the Program substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner, which would result in flooding on- or off site?	No, Program activities would not substantially change or alter drainage amount, timing, or patterns. Drainage channels are maintained to improve water circulation to avoid breeding areas for mosquitoes.
Would the Program create or contribute runoff water, which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?	No, Program activities would not create or contribute additional sources of clean or polluted runoff.
Would the Program place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?	No, Program activities would not construct any housing.
Would the Program place within a 100-year flood hazard area structures, which would impede or redirect flood flows?	No, Program activities would not create any structures.
Would the Program expose people or structures to a significant risk of loss, injury or death involving flooding, including flooding as a result of the failure of a levee or dam?	No, Program activities would not expose people or structures to flooding.
Would the Program lead to inundation by seiche, tsunami, or mudflow?	No, Program activities would not cause inundation by seiche, tsunami, or mudflow.

Topic areas that may be impacted by the Proposed Program include the following:

> Would the Program violate any water quality standards or waste discharge requirements?

> Would the Program otherwise substantially degrade water quality?

For the evaluation of these topic areas, impacts from Program activities on the water quality of surface water or groundwater would be considered potentially significant if the Program implementation or activities could cause chemical concentrations to exceed the following criteria:

> Any discharge to the surface water or groundwater that exceeds NPDES permit receiving water limitations

> Any discharge to the surface water or groundwater that exceeds Basin Plan objectives with a focus on the toxicity objective

> Any discharge to the surface water or groundwater that exceeds the MCLs

> Any discharge to surface water or groundwater that exceeds the California Toxics Rule Criteria Maximum Concentrations for human health or for aquatic life

> Any discharge to surface water or groundwater that degrades the water quality either by affecting beneficial uses or by exceeding any prescribed concentration limits in state water quality plans and policies.

9.2.2 Evaluation Methods and Assumptions

The methodology and assumptions of this water resources impact evaluation for the Program alternatives are provided below.

9.2.2.1 Methodology

The methodology used to prepare this programmatic impact analysis section is as follows:

> Obtain source-specific data for Program-specific chemical constituents.

> Evaluate Ecological and Human Health Risk Assessment (Appendix B) sections related to the District's Program.

> Compare water quality conditions associated with Program alternatives against water quality threshold criteria.

> Identify water resource impacts and mitigation measures for Program activities that exceed water quality thresholds.

The *Ecological and Human Health Risk Assessment* (Appendix B) reviews and evaluates the pesticide (insecticides and herbicides) active ingredients and adjuvants the District currently uses or proposes to use. Application information, including the target organisms, number of treatments, total amount applied, and specific habitat types was obtained from the District. A comprehensive literature review was conducted to evaluate environmental fate and general toxicity characteristics for the active ingredients. The results of the assessment were used to rank the potential for adverse effects to human health and the environment. Chemical and application characteristics such as the likelihood for nontarget species and habitats to be affected, the potential for drift, and the possible transport and fate of the chemical in various media (i.e., air, surface water/groundwater, soil) were considered in the assessment. Those active ingredients that appear to exhibit a higher level of risk than others or that are (or could be) in prevalent use in the District's Program (even though they had lower toxicity) include the following products:

> Methoprene for mosquito control (toxicity to aquatic organisms and insects)

> Etofenprox for mosquito control (toxicity to aquatic organisms)

> Bti for mosquito control (prevalent use; public concerns)

> Pyrethrins for mosquito control (prevalent use; includes PBO synergist)

> Resmethrin for mosquito control (prevalent use; includes PBO synergist)

> Vegetable oil (coconut oil)/mix for mosquito control (contains low percentage petroleum distillate)

> Permethrin for mosquito and wasp control (toxicity to aquatic organisms; potential endocrine disruptor)

> Alkylphenol ethoxylates (APEs) for vegetation control (high toxicity to aquatic organisms; moderately bioaccumulative)

> Glyphosate for general vegetation control (prevalent use; possible endocrine disruptor)

The District is using the following BMPs as control measures to avoid and minimize impacts to water resources (Table 9-3 below; a subset of practices in Table 2-6 in Chapter 2).

Table 9-3 MSMVCD BMPs to Avoid/Minimize Environmental Impacts to Water Resources

Best Management Practice (BMP)
A. General BMPs
1. District staff has had long standing and continues to have cooperative, collaborative relationships with federal, state, and local agencies. The District regularly communicates with agencies regarding the District's operations and/or the necessity and opportunity for increased access for surveillance, source reduction, habitat enhancement, and the presence of special-status species and wildlife. The District often participates in and contributes to interagency projects. The District will continue to foster these relationships, communication, and collaboration.
3. When walking or using small equipment in marshes, riparian corridors, or other sensitive habitats, existing trails, levees and access roads will be used whenever possible to minimize or avoid impacts to species of concern and sensitive habitats. Specific care will be taken when walking and performing surveillance in the vicinity of natural and man-made ditches or sloughs or in the vicinity of tidal marsh habitat.
10. Properly train all staff, contractors, and volunteer help to prevent spreading weeds and pests to other sites. The District headquarters contains wash rack facilities (including high-pressure washers) to regularly (in many cases daily) and thoroughly clean equipment to prevent the spread of weeds.
B. Tidal Marsh-Specific BMPs
1. District will minimize the use of equipment (e.g., ARGOs) in tidal marshes and wetlands. When feasible and appropriate, surveillance and control work will be performed on-foot with handheld equipment. Aerial treatment (helicopter and fixed-wing) treatments will be used when feasible and appropriate to minimize the disturbance of the marsh during pesticide applications. When ATVs (e.g., ARGOs) are used, techniques will be employed that limit impacts to the marsh including: slow speeds; slow, several point turns; using existing levees or upland to travel through sites when possible; use existing pathways or limit the number of travel pathways used.
3. District will minimize travel along tidal channels and sloughs to reduce impacts to vegetation used as habitat (e.g., Ridgway's rail nesting and escape habitat).
5. When feasible, boats will be used to access marsh areas for surveillance and treatment of vectors to further reduce the risk of potential impacts that may occur when using ATVs to conduct vector management activities.
F. Vegetation Management
1. Consultations will be made with the appropriate resource agency to discuss proposed vegetation management work, determine potential presence of sensitive species and areas of concern, and any required permits.
2. Vegetation management work performed will typically be by hand, using handheld tools, to provide access to vector habitat for surveillance, and when needed control activities. Tools used include machetes, small garden-variety chainsaw, hedge trimmers, and "weed-eaters."
3. District will consult and coordinate with resource agencies as well as have all necessary permits prior to the commencement of work using heavy equipment (e.g., larger than handheld/garden variety tools such as small excavators with rotary mowers) in riparian areas.
4. Minor trimming of vegetation (e.g., willow branches approximately 3 inches in diameter or less, blackberry bushes, and poison oak) to the minimum extent necessary will occur to maintain existing paths or create access points through dense riparian vegetation into vector habitat. This procedure may include minor trimming of overhanging limbs, brush and blackberry thickets that obstruct the ability to walk within creek channels. Paths to be maintained will not be a cut, defined corridor but rather a path maintained by selective trimming of overhanging or intrusive vegetation. Paths to be maintained will range in width from 3 to 6 feet across.

Best Management Practice (BMP)
5. Downed trees and large limbs that have fallen due to storm events or disease will be cut only to the extent necessary to maintain existing access points or to allow access to vector habitats.
7. Every effort will be made to complete vegetation management in riparian corridors prior to the onset of heavy rains. Maintenance work to be done in early spring will be limited to trimming new tree shoot growth, poison oak, blackberries, and downed trees that block these paths.
9. Within suitable habitat for California freshwater shrimp (*Syncaris pacifica*), no in-channel vegetation will be removed, trimmed, or otherwise disturbed. District staff will work with resource agencies to determine locations of suitable habitat for California freshwater shrimp and receive written authorization to proceed prior to commencement of vegetation management activities.
10. If suitable habitat necessary for special- status species is found, including vernal pools, and if nonchemical physical and vegetation management control methods have the potential for affecting special- status species, then the District will coordinate with the CDFW, USFWS, and/or NMFS before conducting control activities within this boundary or cancel activities in this area. If the District determines no suitable habitat is present, control activities may occur without further agency consultations.
11. When using heavy equipment for vegetation management, District staff (and contractors) will minimize the area that is affected by the activity and employ all appropriate measures to minimize and contain turbidity. Heavy equipment will not be operated in the water and appropriate containment and cleanup systems will be in place on site to avoid, contain, and clean up any leakage of toxic chemicals.
G. Maintenance / Construction and Repair of Tide Gates and Water Structures in Waters of the US
1. District staff will consult with appropriate resource agencies (USACE, USFWS, CDFW, NMFS, BCDC, RWQCB) and obtain all required permits prior to the commencement of ditch maintenance or construction within tidal marshes.
5. Staging of equipment will occur on upland sites.
6. Mats or other measures will be taken to minimize soil disturbance (e.g., use of low ground pressure equipment) when heavy equipment is used.
7. All projects will be evaluated prior to bringing mechanical equipment on site, to identify and flag sensitive sites, select the best access route to the work site consistent with protection of sensitive areas, and clearly demarcate work areas.
8. Measures will be taken to minimize impacts from mechanical equipment, such as hand ditching as much as possible; reducing turns by track-type vehicles, taking a minimum number of passes with equipment, varying points of entry, driving vehicles at low speed, and not driving on open mud and other soft areas.
9. Discharges of dredged or fill material into tidal waters will be minimized or avoided to the maximum extent possible at the project site and will be consistent with all permit requirements for such activity. No discharge of unsuitable material (e.g., trash) will be made into waters of the US, and material that is discharged must be free of toxic pollutants in toxic amounts (see CWA Section 307). Measures will be taken to avoid disruption of the natural drainage patterns in wetland areas.
11. Ditching that drains high marsh ponds will be minimized to the extent possible to protect the habitat of native salt pan species.
12. No spoils sidecast adjacent to circulation ditches will exceed 8 inches above the marsh plain to minimize risk of colonization of spoils by invasive, nonnative plants and/or the spoils lines from becoming access corridors for unwanted predators (e.g., dogs, cats, red fox). Sidecast spoil lines exceeding 4 inches in height above the marsh plain will extend no more than 6 feet from the nearest ditch margin. Any spoils in excess of these dimensions will be hydraulically redispersed on site (e.g., by rotary ditcher), or removed to designated upland sites (per conditions of resource agency issued permits). Sidecast spoil lines will be breached at appropriate intervals to prevent local impediments to water circulation.

Best Management Practice (BMP)
14. Small ditch maintenance work will be performed by hand, whenever possible, using handheld shovels, pitch forks, etc., and small trimmers such as "weed-eaters." (Note: the majority of small ditch work the District performs is by hand.)
15. Work will be done at low tide (for tidal areas) and times of entry will be planned to minimize disruption to wildlife.
16. In marshes that contain populations of invasive nonnative vegetation such as pepperweed or introduced spartina, sidecast spoils will be surveyed for the frequency of establishment of these species during the first growing season following deposition of the spoils. The results of the surveys will be reported to the USACE, USFWS, and CDFW. If it is determined the sidecasting of spoils resulted in a substantial increase in the distribution or abundance of the nonnative vegetation, which is detrimental to the marsh, the District will implement appropriate abatement measures after consultation with the USACE, USFWS, and CDFW.
17. When possible (i.e., with existing labor and vehicles), refuse such as tires, plastic, and man-made containers found at the work site will be removed and properly discarded.
H. Applications of Pesticides, Surfactants, and/or Herbicides
1. District staff will conduct applications with strict adherence to product label directions that include approved application rates and methods, storage, transportation, mixing, and container disposal.
2. District will avoid use of surfactants when possible in sites with aquatic nontargets or natural enemies of mosquitoes present such as nymphal damselflies and dragonflies, dytiscids, hydrophilids, corixids, notonectids, and ephydrids. Surfactants are the only tool that can be used with pupae to prevent adult mosquito emergence. The District will use a microbial larvicide (Bti, Bs), insect growth regulator (e.g., methoprene) instead, or another alternative when possible.
3. Materials will be applied at the lowest effective concentration for a specific set of vectors and environmental conditions. Application rates will never exceed the maximum label application rate.
4. To minimize application of pesticides, application of pesticides will be informed by surveillance and monitoring of vector populations.
5. District staff will follow label requirements for storage, loading, and mixing of pesticides and herbicides. Handle all mixing and transferring of pesticides and herbicides within a contained area.
6. Postpone or cease application when predetermined weather parameters exceed product label specifications, when wind speeds exceed the velocity as stated on the product label, or when a high chance of rain is predicted and rain is determining factor on the label of the material to be applied.
7. Applicators will remain aware of wind conditions prior to and during application events to minimize any possible unwanted drift to waterbodies, and other areas adjacent to the application areas.
8. Spray nozzles will be adjusted to produce larger droplet size rather than smaller droplet size. Use low nozzle pressures where possible (e.g., 30 to 70 pounds per square inch). Keep spray nozzles within a predetermined maximum distance of target weeds (e.g., within 24 inches of vegetation for hand application) or vectors. Adjusting droplet size would only apply to larvicides, herbicides, and non-ULV applications. Use ULV applications that are calibrated to be effective and environmentally compatible at the proper droplet size (about 10 to 30 microns).
9. Clean containers at an approved site and dispose of at a legal dumpsite or recycle in accordance with manufacturer's instructions if available.
10. Special-Status Aquatic Wildlife Species: – A CNDDB search was conducted in 2012 and the results incorporated into Appendix A for this PEIR. An update was completed in November 2014 and the results incorporated into Section 4.1.2 of this PEIR. District staff communicates with state, federal, and county agencies regarding sites that have potential to support special-status species. Staff have visited many sites where the District performs surveillance and control work for many years and staff are highly knowledgeable about the sites and habitat present. If new sites or site features are discovered that have potential to be habitat for special-status species, the appropriate agency and/or landowner is contacted and communication initiated.

Best Management Practice (BMP)
– Use only pesticides, herbicides, and adjuvants approved for aquatic areas or manual treatments within a predetermined distance from aquatic features (e.g., within 15 feet of aquatic features). Aquatic features are defined as any natural or man-made lake, pond, river, creek, drainage way, ditch, spring, saturated soils, or similar feature that holds water at the time of treatment or typically becomes inundated during winter rains. – If suitable habitat for special-status species is found, including vernal pools, and if aquatic-approved pesticide, herbicide, and adjuvant treatment methods have the potential for affecting the potential species, then the District will coordinate with the CDFW, USFWS, and/or NMFS before conducting treatment activities within this boundary or cancel activities in this area. If the District determines no suitable habitat is present, treatment activities may occur without further agency consultation.
11. District staff will monitor sites post-treatment to determine if the target vector or weeds were effectively controlled with minimum effect to the environment and nontarget organisms. This information will be used to help design future treatment methods in the same season or future years to respond to changes in site conditions.
12. Do not apply pesticides that could affect insect pollinators in liquid or spray/fog forms over large areas (more than 0.25 acre) during the day when honeybees are present and active or when other pollinators are active. Preferred applications of these specific pesticides are to occur in areas with little or no honeybees or pollinator activity or after dark. These treatments may be applied over smaller areas (with handheld equipment), but the technician will first inspect the area for the presence of bees and other pollinators. If pollinators are present in substantial numbers, the treatment will be made at an alternative time when these pollinators are inactive or absent.
13. The District will provide notification to the public (24 to 48 hours in advance if possible) and/or appropriate agency(ies) when applying pesticides or herbicides for large-scale treatments that will occur in close proximity to homes, heavily populated, high traffic, and sensitive areas. The District infrequently applies or participates in the application of herbicides in areas other than District facilities.
I. Hazardous Materials and Spill Management
1. Exercise adequate caution to prevent spillage of pesticides during storage, transportation, mixing, or application of pesticides. Report all pesticide spills and cleanups (excepting cases where dry materials may be returned to the container or application equipment).
2. Maintain a pesticide spill cleanup kit and proper protective equipment at the District's Service Yard and in each District truck used for pesticide transport.
3. Manage the spill site to prevent entry by unauthorized personnel. Contain and control the spill by stopping it from leaking or spreading to surrounding areas, Cover dry spills with polyethylene or plastic tarpaulin, and absorb liquid spills with appropriate absorbent materials.
4. Properly secure the spilled material, label the bags with service container labels identifying the pesticide, and deliver them to a District/Field Supervisor for disposal.
5. A hazardous spill plan will be developed, maintained, made available, and staff trained on implementation and notification for petroleum-based or other chemical-based materials prior to commencement of vector treatment activities.
6. Field-based mixing and loading operations will occur in such a manner as to minimize the risk of accidental spill or release of pesticides.

9.2.2.2 Assumptions

The following assumptions were used in the assessment of potential water resource impacts from the Program alternatives:

> Site-specific evaluation of water quality impacts are not within the scope of this programmatic evaluation.

> The programmatic evaluation is based on the current proposed mosquito and/or vector control methods and is subject to change.

> Existing baseline ambient water quality data related to Program chemicals are limited for most areas.

> Mitigation measures for specific locations within the Program Area are not provided. The BMPs listed above will be implemented by the District as needed throughout the District's Service Area.

Assumptions related to the analysis of hazards, toxicity, and exposure for chemical treatment methods are explained below, including the definition of key terms.

9.2.2.2.1 Hazardous Material

A "hazardous material" is defined in California Health and Safety Code Section 25501 (p): as "any material that, because of its quantity, concentration, or physical or chemical characteristics, poses a significant present or potential hazard to human health and safety or to the environment if released into the workplace or the environment. "Hazardous materials" include, but are not limited to, "hazardous substances, hazardous waste, and any material that a handler or the administering agency has a reasonable basis for believing that it would be injurious to the health and safety of persons or harmful to the environment if released into the workplace or the environment." Any liquid, solid, gas, sludge, synthetic product, or commodity that exhibits characteristics of toxicity, ignitability, corrosiveness, or reactivity has the potential to be considered a "hazardous material."

9.2.2.3 Toxicity and Exposure

Toxicology is the study of a compound's potential to elicit an adverse effect in an organism. The toxicity of a compound is dependent upon exposure, including the specific amount of the compound that reaches an organism's tissues (i.e., the dose), the duration of time over which a dose is received, the potency of the chemical for eliciting a toxic effect (i.e., the response), and the sensitivity of the organism receiving the dose of the chemical. Toxicity effects are measured in controlled laboratory tests on a dose/response scale, whereby the probability of a toxic response increases as dose increases. Exposure to a compound is necessary for potential toxic effects to occur. However, exposure does not, in itself, imply that toxicity will occur. Thus, toxic hazards can be mitigated by limiting potential exposure to ensure that doses are less than the amount that may result in adverse health effects.

The toxicity data included in the numerous tables and charts in this document are generally derived from rigidly controlled laboratory animal studies designed to determine the potential adverse effects of the chemical under several possible routes of exposure. In these studies, the species of interest is exposed to 100 percent chemical at several doses to determine useful information such as the lowest concentration resulting in a predetermined adverse effect (LOAEL) on numerous selected physiological and behavioral systems. The second component of these tests is to determine the highest concentration of chemical that results in no measurable adverse effect (NOAEL).

However, these and other coordinated and focused laboratory tests are designed to document the effects of the chemical using a continuous, controlled laboratory exposure that does not realistically reflect the likely patchy exposures typical of the District field application scenarios. As such, the toxicity information generated using laboratory tests (and some limited field tests) are intended as an overview of potential issues that might be associated with maximum direct exposures. This information is used to develop and recommend guidance for use that should provide maximum exposure levels of applications that are

protective of ecological health. These guidelines include numerous “safety margins” in the toxicity calculations that are intended to provide adequate efficacy to target organisms while not adversely impacting humans or nontarget plant and animal species. In some instances, the regulatory guidance may include additional suggestions for protective application to assure no significant impact on nontarget species and humans.

Although the regulatory community uses this basic information to provide a relative comparison of the potential for a chemical to result in unwanted adverse effects and this information is reflected in the approved usage labels and material safety data sheets (MSDSs),[1] in actual practice, the amounts applied in the District’s Program Area are substantially less than the amounts used in the toxicity studies.

Because of the large safety factors used to develop recommended product label application rates, the amount of chemical resulting in demonstrated toxicity in the laboratory is much higher than the low exposure levels associated with an actual application for vector control. The application concentrations consistent with the labels or MSDSs are designed to be protective of the health of humans and other nontarget species (i.e., low enough to not kill them, weaken them, or cause them to fail to reproduce). Although numerous precautions (BMPs) and use of recommended application guidance is intended to provide efficacy without adverse effects to nontarget organisms, misapplication or unexpected weather conditions may still result in effects on some nontarget organisms in the exposure area (see Section 6.2 for analysis of these potential impacts) . This potential impact is ameliorated by careful use of BMPs and advance planning by the District.

Although laboratory toxicity testing focuses on tiered concentrations of chemical exposure, the results of these tests produce a series of toxicity estimates of concentrations less than those that produce mortality. Extrapolation of these data is used to generate estimates of chronic toxicity or possible effects of lower doses that may result in sublethal effects such as reproduction or metabolic changes. In reality, these low-dose exposures need to be sustained over longer periods than are relevant to typical application scenarios for vector control including multiple applications in an area such as a wetland.

9.2.3 Surveillance Alternative

Surveillance activities involve monitoring the abundance of adult and larval mosquitoes, field inspection of mosquito habitat, testing for the presence of encephalitis virus-specific antibodies in sentinel chickens or wild birds, collection and testing of ticks, small rodent trapping and testing, and/or response to public service requests regarding other animal or insect vectors. Mosquito populations are monitored through the use of traps, inspections, and sampling in mosquito habitats. Known and suspected habitats are anywhere that water can collect, be stored, or remain standing for more than a few days, including, but not limited to, catch basins, stormwater detention systems, residential communities, parks, ornamental ponds, unmaintained swimming pools, seeps, seasonal wetlands, tidal and diked marshes, wastewater ponds, malfunctioning septic (onsite wastewater treatment) systems, sewer plants, winery waste/agricultural ponds, managed waterfowl ponds, canals, creeks, tree holes, and flooded basements. Inspection of a septic system as a source of mosquito production is typically performed in response to a request for service from property owners. Indirect surveillance for mosquitoes associated with septic tanks and leach fields is conducted by setting adult mosquito traps on individual properties or within neighborhoods. Ticks and rodents are collected along trails and sampled for disease. Rodents may be collected during building inspections or ongoing service requests.

The potential for increased soil erosion during surveillance activities would be minimal. Existing trails, levees, and access roads will be used whenever possible when walking or using small equipment in marshes or other sensitive habitats (BMP A3). Boats would also be used to access marsh areas during

[1] Although the MSDS format is referenced in this document, note that under the international Globally Harmonized System, the MSDS format has been substantially revised and is now largely replaced by standardized Safety Data Sheets (SDSs).

surveillance (BMP B5). If preexisting roads and trails are not available, low ground pressure ATVs may be used to access sites. Offroad access is minimized and used only when roads and trails are not available.

> **Impact WR-1:** The Surveillance Alternative would not result in increased soil erosion, so the impact to surface water would **be less than significant**. No mitigation is required.

Surveillance activities do not involve chemical applications to water or soil and require very little interaction with waterbodies to collect samples. With the exception of some adult mosquito traps, pesticides are not required for any of the surveillance techniques. Some adult mosquito traps use a Vapona strip infused with dichlorvos in the bottom of the collection jar; this chemical would be contained in the collection device and would not contact nor interact with the environment. Emergence traps for mosquitos may contain octanol. Emergence traps are typically a pyramid-shaped, floating trap with a collection jar at the apex that collects adult mosquitoes as they emerge from the water surface. The chemical materials in the collection jar would not have a direct contact or interaction with the environment. Therefore, no impact would occur to surface water or groundwater.

> **Impact WR-2:** The Surveillance Alternative collection devices would not contact nor interact with the environment. **No impact** would occur to surface water or groundwater.

9.2.4 Physical Control Alternative

Physical controls for mosquitoes consists of the direct management of mosquito-producing habitat (including freshwater marshes and lakes, saltwater marshes, temporary standing water, septic tank systems, and wastewater treatment facilities) especially through water control and maintenance or improvement of channels, tide gates, levees, and other water control facilities, or indirect habitat management through public education (see Section 2.4). Physical controls reduce or eliminate mosquito development sites by improving the habitat value for mosquito predators (i.e., providing deepwater sanctuary for larvivorous fish) or by reducing the habitat value for mosquitoes. Because mosquitoes breed in stagnant standing water, the District attempts to reduce these habitats through vegetation management (discussed in Section 9.2.5), increased circulation, steepening banks, changes in water quality, or by reducing the duration that standing water is allowed to persist. The specific method employed is based on site- and project-specific considerations, including whether the activity is conducted to prevent mosquito-producing habitat from forming or in response to existing conditions. Characteristics of the site and waterbody are also considered in planning physical control activities. If mosquito production is found within a septic system, the resident and/or property owner is informed of source reduction measures that they need to research and implement (if applicable) to prevent mosquito production from occurring in the onsite wastewater system and its associated plumbing system. Examples of source reduction measures include inspecting septic tank lids for cracks (and fixing the cracks if present), ensuring the lid gasket (if so equipped) is in good condition, and ensuring that a proper seal occurs when the fasteners are tightened, determining if risers are present and exposed and that they are free of cracks, and ensuring that all vents to the system, including those on the roof of the building, are completely covered with a durable 1/16-inch mesh screen type material. The District conducts physical control activities, requests landowners and stewards to implement maintenance activities, and advises landowners on source reduction for mosquito habitat. Any requests to landowners and stewards will include a clear statement regarding the need for consultation with resource agencies to determine potential risks to sensitive habitats and special-status species as well as to determine the need for any permits prior to commencement of any work.

Three types of physical control practices are implemented:

1. Maintenance activities include removal of sediments from existing water circulation ditches; repair of existing water control structures, removal of debris in natural channels, clearance or trimming of brush for access to streams tributary to wetland areas, and filling of existing, nonfunctional water circulation ditches to achieve required water circulation dynamics and restore ditched wetlands.

2. New construction typically involves the creation of new ditches to enhance tidal flow preventing stagnant water.
3. Cultural practices include vegetation (i.e., clearing of vegetation in canals) and water management (i.e., irrigation and inundation practices), placement of culverts or other engineering works, and making other physical changes to the lands.

The District performs these physical control activities in accordance with all appropriate environmental regulations and in a manner that generally maintains or improves habitat values for desirable species. Physical control activities can be relatively minor, typically consisting of up to 10,000 linear feet of ditch maintenance per year, and are often covered by the District's 5-year USACE, SWRCB/RWQCB, and BCDC regional wetlands permits (Section 2.8.1.3). Filling or periodically draining artificially ponded areas such as ornamental ponds and irrigation ponds can be cost-effective and environmentally acceptable; however, these methods are not appropriate strategies in natural areas, in large permanent waterbodies, or in areas set aside for stormwater or wastewater retention. Consequently, the District does not usually construct new physical control projects in freshwater bodies including marshes and ponds. In saline and brackish marsh habitat, physical control measures are typically designed to reduce salt-marsh mosquito production through enhancement of the frequency and duration of tidal inundation or through other water management strategies.

Physical control activities for other vectors such as rats and mice are based on the District's site inspections. They may include education of property owners on sanitation, exclusion, and rodent proofing. The District may also remove the vector, typically by trapping methods under the Nonchemical Control/Trapping Alternative.

Maintenance of existing facilities, construction of new water control facilities and changes in water management strategies could affect existing drainage patterns and water quality locally. However, existing trails, levees, and access roads will be used whenever possible when walking or using small equipment in marshes or other sensitive habitats (BMP A3). Furthermore, the District will implement control measures during ditch maintenance and during construction or repair of tide gates and other water control structures in tidal marshes to avoid disruption to natural drainage patterns (BMP G9). For example, spoil material sidecast during ditch maintenance would not exceed 4 inches above the marsh plain within 6 feet of the ditch or exceed 8 inches above the marsh plain at further distances, and the sidecast material would be breached periodically to not impede local runoff (BMP G12). Because physical control activities would typically be implemented to improve drainage at the site and reduce the duration of standing water in areas that produce mosquitoes and because control measures will be used to minimize disruption of natural drainage patterns, these activities would not adversely and substantially change or alter drainage amounts, timing, or patterns or substantially increase soil erosion. Furthermore, permitted projects are typically inspected by resource agency personnel to confirm that permit conditions were met.

Physical controls would likely improve long-term water quality conditions. Physical control activities would be designed to improve drainage or increase water circulation, which can increase dissolved oxygen and reduce water temperatures, improving these water quality conditions locally. Although modifying water circulation patterns could increase localized areas of scour due to increased water velocities, particularly near structures, water control facilities (e.g., tide gates, levees) would be designed using best engineering practices to minimize scour and soil erosion near the structure for long-term stability. Potential increases in turbidity in the waterbody would be limited to during and immediately after the action and would not extend beyond the vicinity of the area being improved. Changes to groundwater conditions such as water quality or recharge would not occur.

Removal of sediments from existing water circulation ditches during maintenance activities has the potential to temporarily approach or exceed turbidity water quality objectives in nearby downstream receiving waters. However, maintenance activities are short in duration (often less than 1 day), are localized to site-specific areas, and are transitory in location. Additionally, a majority of small ditch work is

performed by hand (BMP G14), limiting the amount of ground-disturbing activity that could occur when maintaining these areas, and other control measures will be used to minimize soil disturbance and erosion near waterways (BMPs G5, G6, and G8). Therefore, this temporary and transitory potential impact to surface water or groundwater is less than significant.

> **Impact WR-3**: The Physical Control Alternative's activities to modify water circulation, remove sediment, and maintain water control facilities to reduce habitat conditions for mosquito production would have a **less-than-significant** impact on soil erosion and water resources and no mitigation is required.

9.2.5 Vegetation Management Alternative

District staff's direct vegetation management generally consists of activities to reduce the mosquito habitat value of sites by improving water circulation or access by fish and other predators, or to allow District staff's access to standing water and known sources of mosquito production for inspections and treatment. The District uses hand tools, other mechanical means, or herbicide applications to thin or remove vegetation. These activities primarily occur in aquatic habitats to assist with the control of mosquitoes but are also implemented in terrestrial habitats to help with the control of other vectors. The District may also perform vegetation management to assist other agencies and landowners with the management of invasive/nonnative weeds in vector habitats. These actions are typically performed under the direction of the concerned agency, which also maintains any required permits.

9.2.5.1 Mechanical Removal of Vegetation

Vegetation management work in riparian areas is typically performed by hand, using handheld tools, prior to the onset of heavy rains (BMPs F2 and F7). If heavy equipment is needed, control measures will be used to minimize the affected area, minimize soil erosion, minimize and contain turbidity, and avoid, contain, and clean up any leakage of toxic materials (BMP F11). Mechanical and hand removal of vegetation from aquatic habitats has the potential to temporarily approach or exceed turbidity water quality objectives in downstream receiving waters. However, the vegetation control activities are short in duration (typically less than 1 day), are localized to site-specific areas, and are transitory in location. Therefore, this temporary and transitory potential impact to surface water is less than significant. No impact to groundwater is associated with these activities.

> **Impact WR-4:** Mechanical removal of vegetation from aquatic habitats would have a **less-than-significant** impact to surface water and **no impact** to groundwater resources. No mitigation is required.

9.2.5.2 Herbicide Application

Herbicides the District has used in the past or could use in the future are listed in Table 2-1 along with information regarding the timing/season of application, method of application, and types of sites where they are applied. Section 4.6 of the *Ecological and Human Health Assessment Report* (Appendix B) includes descriptions of each herbicide and information on their environmental fate and toxicity.

Potential effects from applications of herbicides include low dissolved oxygen, aquatic toxicity to nontarget species, and contributions to instream exceedances of water quality criteria, particularly if applied in previously impacted waterbodies. For example, the water quality objective that establishes a minimum concentration for dissolved oxygen may not be met in some instances, such as when aquatic weeds killed by herbicides decompose rapidly and consume dissolved oxygen in the process. Some herbicide applications also have the potential to approach or exceed the narrative toxicity water quality objective, numeric water quality objective, or receiving water monitoring trigger for the specific active ingredient. Herbicides that are not labeled for aquatic use and are subject to potential spray drift or surface water runoff may cause acute or chronic toxicity.

However, the District will apply all herbicides in strict conformance with label requirements, which have been approved by CDPR for use in California (BMP H1). Pesticide labels are legal requirements and include instructions telling users how to apply the product and precautions the applicator should take to protect human health and the environment. Herbicide applications will comply with label restrictions on application rates and methods, storage, transportation, mixing, and container disposal and by BMPs H1, H3, H5, H6, and H9. In addition, aquatic herbicides are applied in conformance with the APAP as required by the NPDES Aquatic Weed Control Permit.

The District will implement label requirements and District BMPs to reduce potential adverse effects to surface and groundwater resources from applied chemicals during and following herbicide applications. Materials will be applied at the lowest effective concentration for the environmental conditions (BMP H3). Spray nozzles will be adjusted to produce larger droplet size rather than smaller droplet size, low nozzle pressures would be use where possible, and spray nozzles will be maintained at a predetermined maximum distance from target vegetation (BMP H8). Applicators will be aware of wind conditions, to minimize unwanted drift to waterbodies and adjacent areas, and aware of potential rain, if rain is a determining factor on material application (BMPs H6 and H7). If special-status aquatic wildlife species are potentially present, only herbicides and adjuvants approved for aquatic areas will be applied within a predetermined distance from aquatic features (BMP H10).

The District will also implement hazardous materials and spill management control measures to prevent and reduce potential exposure of spilled chemicals to surface and groundwater resources (BMPs I1 through I6). These measures will require development and implementation of a hazardous spill plan and procedures used to minimize the risk of an accidental spill or release. District control measures also require that mixing and transferring of materials will occur within a contained area (BMP H5) and materials will be disposed at an approved site (BMP H9).

District staff will monitor sites post-treatment to determine if the target weeds were effectively controlled with minimum impact to the environment and nontarget organisms. This information will be used to help design future treatment methods in the same season or future years to respond to changes in site conditions (BMP H11). Implementation of these BMPs will reduce exposure of applied chemicals to surface and groundwater resources during and following application of the material.

Herbicides and adjuvants the District may use are grouped below based on toxicity to fish and aquatic invertebrates. They are discussed in more detail in Appendix B, *Ecological and Human Health Assessment Report* (Sections 4.6 and 4.7, respectively).

9.2.5.2.1 Registered Herbicides with Relatively Low Toxicity to Fish and Aquatic Invertebrates

Imazapyr is a systemic, nonselective, pre- and post-emergent herbicide used for the control of a broad range of terrestrial and aquatic weeds, including terrestrial annual and perennial grasses, broadleaf herbs, woody species, and riparian and emergent aquatic species. Imazapyr is water-soluble, can run off to surface waterbodies, and degrades in clear, open water. However, it is persistent in soil and leaches to groundwater. It has low toxicity to fish and aquatic invertebrates. Based upon imazapyr's toxicity and environmental fate, and using District BMP application techniques, these products would result in minimal, if any, adverse effects.

Glyphosate is a nonselective, post-emergent, and systemic herbicide registered for use in agricultural and nonagricultural areas. It is used to control emergent foliage, but is not effective on submerged or mostly submerged foliage. Glyphosate is highly water-soluble, but binds tightly to soil and sediments. It has a low tendency to run off when applied to land because of strong adsorption to soil particles and it has a low potential to move to groundwater. Glyphosate degrades in soil in about a month. It has low toxicity to fish and aquatic invertebrates.

The District will apply all herbicide formulations following District BMPs and in strict conformance with their APAPs (if applicable) and label requirements, which have been approved by CDPR for use in California.

District BMP application techniques and using care during herbicide applications will minimize adverse effects and substantially avoid degradation of water quality. Therefore, application of these herbicide active ingredients (i.e., imazapyr and glyphosate) would have a less-than-significant impact to surface water or groundwater resources when applied in accordance with label instructions and District BMPs.

> **Impact WR-5:** Application of the herbicides imazapyr and glyphosate would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.

9.2.5.2.2 Registered Herbicides with Moderate Toxicity to Fish or Aquatic Invertebrates

Triclopyr is used for the control of woody plants and annual and perennial broadleaf weeds. It is absorbed by leaves and roots and is moved throughout the plant into the foliage. Triclopyr is highly soluble, is moderately persistent in soil (with sorption to soil increasing with time), but degrades rapidly in clear, open water. It is moderate to highly toxic to fish, but is practically nontoxic to invertebrates. Based upon triclopyr's toxicity and environmental fate, implementation of District BMPs, and using recommended BMP application techniques, these products should result in minimal, if any, adverse effects.

The District will apply all herbicide formulations following District BMPs and in strict conformance with their APAPs (if applicable) and label requirements, which have been approved by CDPR for use in California. District BMP application techniques and using care during herbicide applications will minimize adverse effects and substantially avoid degradation of water quality. Therefore, application of this herbicide active ingredient (i.e., triclopyr) would have a less-than-significant impact to surface and groundwater resources when applied in accordance with label instructions and District BMPs.

> **Impact WR-6:** Application of the herbicide triclopyr would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.

9.2.5.2.3 Adjuvants with High Toxicity to Fish or Aquatic Invertebrates

Alkylphenol ethoxylates (APEs) are identified in Appendix B, *Ecological and Human Health Assessment Report* (Section 4.7.1) as having high toxicity to fish or other aquatic organisms. APEs include a broad range of chemicals that act as adjuvants. APEs bind strongly to aquatic particles in river and coastal environments and are persistent in sediments. Nonylphenol and short-chain nonylphenol ethoxylates are moderately bioaccumulative[2] and extremely toxic to aquatic organisms. The USEPA has recently recommended that nonylphenol and short-chain ethoxylates be evaluated further due to their widespread use (past and present), persistence, and possible estrogen-mimicking behavior. Potential contamination of surface water runoff and groundwater is particularly high for highly soluble or highly mobile chemicals.

The District will apply all herbicide formulations and adjuvants following District BMPs and in strict conformance with their APAPs (if applicable) and label requirements, which have been approved by CDPR for use in California. District BMP application techniques and using care during herbicide applications will minimize adverse effects and substantially avoid degradation of water quality. Therefore, application of these adjuvants would have a less-than-significant impact to surface and groundwater resources when applied in accordance with label instructions and District BMPs.

> **Impact WR-7:** For APEs, application of these herbicides would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.

[2] Bioaccumulation is defined as the increase in concentration of a chemical from the environment to the first organism in a food chain. For additional information, see Chapter 6 (Sections 6.1.1.3, 6.25, and 6.27).

9.2.5.2.4 Adjuvants with Unknown Toxicity to Fish or Aquatic Invertebrates

Oil adjuvants (modified plant oils and methylated seed oils) can increase the penetration of oil-soluble herbicides into plants. Little is known of the environmental fate of these adjuvants. Modified plant oils and methylated seed oils are essentially nontoxic to most organisms, including plants. Although some information is lacking regarding the toxicity and environmental fate of these oils, these products should result in minimal adverse effects when using District BMP application techniques.

Lecithins are naturally occurring phospholipids in biological cell membranes. Little is known about the toxicity or environmental fate of lecithins. Although some information is lacking regarding the toxicity and environmental fate of these products, use of these products should result in minimal adverse effects when used in accordance with District BMP application techniques.

Furthermore, the District will apply all herbicide formulations and adjuvants following District BMPs and in strict conformance with their APAPs (if applicable) and label requirements, which have been approved by CDPR for use in California. Due to the lack of reported, documented effects of these adjuvants, proper application of methods using District BMP application techniques will minimize adverse effects and substantially avoid degradation of water quality. Therefore, application of these chemicals would have a less-than-significant impact to surface and groundwater resources when applied following label instructions and District BMPs.

> **Impact WR-8:** Application of modified plant oils and lecithins would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.

9.2.6 Biological Control Alternative

Biological control of mosquitoes involves the intentional use of vector pathogens, parasites, and predators to reduce the mosquito population. It is one of the principal components of the IPM approach followed by Mosquito Vector Control Association of California member agencies, in which the emphasis is on source reduction and control of mosquitoes in their immature stages. Mosquito pathogens include an assortment of viruses and bacteria, but the only commercially available mosquito pathogen is the bacterial pathogen *Bacillus sphaericus* or Bs (discussed below in Section 9.2.7, Chemical Control Alternative). Mosquito parasites are not generally available commercially for mosquito control at present. Mosquito predators are represented by insects, fish, birds, and bats that consume larval or adult mosquitoes as prey. Although the District supports the presence of a variety of species, only mosquitofish (*Gambusia affinis*) are commercially available to use at present. Currently, no commercial biological control agents or products are available for tick, wasp, and yellow jacket control, and the District does not employ predators for rodent control.

Wastewater discharges from mosquitofish hatcheries have the potential to convey nutrients, sediments, and other potential pollutants to storm drains, downstream receiving waters, and groundwater. If the wastewater is discharged to a sanitary sewer, the potential pollutants can be removed by the wastewater treatment plant. If the wastewater is discharged to land as irrigation water, natural degradation would provide some level of treatment via chemical, biological, and physical processes that occur as the wastewater flows over and percolates through the soil. However, mosquitofish are no longer reared at District hatchery facilities. The District will purchase mosquitofish from another district and only maintain a small stock of fish in a holding tank on site to meet demand. The wastewater will be discharged to a sanitary sewer, where the potential pollutants can be removed by the wastewater treatment plant. Because the volume and frequency of discharges are relatively minor and to the sanitary sewer, the impact of this alternative to surface water and groundwater is less than significant.

> **Impact WR-9:** The Biological Control Alternative's use of mosquitofish limits wastewater discharges to the sanitary sewer or upland areas. Therefore, the use of mosquitofish would have a **less-than-significant** impact on surface and groundwater resources and no mitigation is required.

Because mosquitofish may potentially impact red-legged frog and tiger salamander populations, use of mosquitofish is limited to man-made water features such as ornamental fish ponds, ponds, water troughs, water gardens, fountains, unmaintained swimming pools, and other types of isolated man-made ponds where their migration into habitats used by special-status species is limited. High populations of mosquitofish in a waterbody could increase nutrient concentrations, causing algal blooms and a subsequent drop in dissolved oxygen. However, because mosquitofish use is limited to man-made water features that are hydrologically isolated from receiving waters, their impact to surface water is less than significant. Because the connection between these man-made waterbodies and natural surface waters or groundwater is limited or nonexistent, the impact of this alternative is less than significant.

> **Impact WR-10:** The Biological Control Alternative's use of mosquitofish is limited to man-made water features that are hydrologically isolated from receiving waters. Therefore, the use of mosquitofish would have a **less-than-significant** impact on surface and groundwater resources and no mitigation is required.

9.2.7 Chemical Control Alternative

Chemical control consists of the application of chemicals to directly reduce populations of vectors that pose a risk to public health (herbicides are discussed in Section 9.2.5, Vegetation Management Alternative). The majority of chemical control tools are used for mosquito abatement. As part of the IVM program, the District prioritizes the least toxic materials available for control of the larval stages, focusing on bacterial larvicides, growth regulators, and surface films rather than pyrethroids. Control of adult mosquitoes may become necessary under some circumstances, such as in the event of a disease outbreak (documented presence of infectious virus in active host-seeking adult mosquitoes), or lack of access to larval sources and habitats leading to the emergence of large numbers of biting adult mosquitoes. The active ingredients currently used for control of adult mosquitoes have been deliberately selected for lack of persistence and minimal effects on nontarget organisms when applied in accordance with label guidelines for ULV mosquito control.

The District also uses insecticides to control populations of ground-nesting yellow jacket wasps. The District does not currently perform control work with respect to tick populations but may potentially do a limited amount of control work in the future. This activity is generally triggered by public or agency requests rather than as a result of regular surveillance activities. The District does not treat yellow jacket wasp nests that are located inside or on a structure; instead, the resident is encouraged to contact a private pest control company. Likewise, residents complaining of honeybee swarms or hives are referred to the County Agricultural Commissioner's Office for a referral list of beekeepers. If a District technician deems it appropriate to treat stinging insects, they will apply the insecticide directly within the nest to avoid drift or harm to other organisms. Alternatively, they will place tamper-resistant traps or bait stations, selective for the target insect in the immediate environment. Chemicals used in the traps are contained and do not interact with the environment. District staff use no rodenticides.

Potential effects from chemical applications of pesticides include increased aquatic toxicity for nontarget species and contributions to instream exceedances of water quality criteria. For example, some chemical applications have the potential to approach or exceed the narrative toxicity water quality objectives, numeric water quality objectives, or receiving water monitoring triggers for the specific active ingredient, particularly if applied in previously impacted waterbodies. However, the District applies all chemicals in strict conformance with label requirements, which have been approved by CDPR for use in California (BMP H1). Pesticide labels are application requirements and include instructions informing users how to apply the product and precautions the applicator should employ to protect human health and the environment. Pesticide applications would comply with label restrictions on application rates and methods, storage, transportation, mixing, and container disposal as well as District BMPs H1, H3, H5, H6, and H9. In addition, chemicals are applied in conformance with the PAP as required by the NPDES

Vector Control Permit. All BMPs included in the PAP and product labels are followed and include such measures as restrictions in applications to certain land uses and weather (i.e., wind speed) parameters.

The District will implement label requirements and District BMPs to reduce adverse effects to surface and groundwater resources from the applied chemicals during and following pesticide applications. To minimize the amount of pesticides, pesticide applications will be informed by surveillance and monitoring of vector populations (BMP H4). Materials will be applied at the lowest effective concentration for the environmental conditions (BMP H3). For non-ULV applications, spray nozzles will be adjusted to produce larger droplet size rather than smaller droplet size, low nozzle pressures will be used where possible, and spray nozzles will be maintained within a predetermined maximum distance from target areas. For ULV applications, sprays will be calibrated for the proper droplet size (BMP H8). Applicators will be aware of wind conditions to minimize unwanted drift to waterbodies and adjacent areas, and aware of potential rain when rain is a determining factor on material application (BMP H6 and H7). Pesticides that could affect insect pollinators will not be applied in liquid or spray/fog forms over large areas (more than 0.25 acre) during the day when honeybees are present and active or when other pollinators are active (BMP H12). If special-status aquatic wildlife species are potentially present, only pesticides and adjuvants approved for aquatic areas will be applied within a predetermined distance from aquatic features (BMP H10) to minimize the potential for interaction with terrestrial wildlife.

The District will also implement hazardous materials and spill management control measures to prevent and reduce potential exposure of spilled chemicals to surface and groundwater resources (BMPs I1 through I6). These measures will require development and implementation of a hazardous spill plan and procedures used to minimize the risk of an accidental spill or release. District control measures also require that mixing and transferring of materials will occur within a contained area (BMP H5) and materials will be disposed at an approved site (BMP H9).

District staff will monitor sites post-treatment to determine if the target vectors were effectively controlled with minimum effect to the environment and nontarget organisms. This information will be used to help design future treatment methods in the same season or future years to respond to changes in site conditions (BMP H11). Implementation of these BMPs will reduce exposure of applied chemicals to surface and groundwater resources during and following application of the material.

All chemical active ingredients and adjuvants the District currently uses are reviewed and evaluated in the *Ecological and Human Health Assessment Report* (Appendix B). The following sections evaluate groups of chemicals based on their target organism or life stage.

9.2.7.1 Mosquito Larvicides

Larvicides are used to manage immature life stages of mosquitoes including larvae and pupae in aquatic habitats. Temporary aquatic habitats are usually targeted because permanent waterbodies generally support natural mosquito predators such as fish. The larvicides are applied using ground application equipment and rotary and/or fixed wing aircraft. Applications may be repeated at any site at recurrence intervals ranging from annually to weekly.

Under some circumstances, and at the request for service from District clients, the District performs mosquito surveillance near septic systems (onsite wastewater treatment systems) by inspecting or removing the lid(s) on the system to determine the presence of larval and/or adult mosquitoes. Or, if mosquito populations are detected via adult mosquito surveillance (e.g., adult mosquito traps) in an area associated with a septic system, the District staff may choose to treat soil and/or surface water in the vicinity of a septic tank that appears to have failed or malfunctioned. In this situation, the District may provide selected mosquito larvicide treatment to the tank and/or the septic leach/drain field and system environs. This treatment is intended to efficiently and effectively break the cycle of mosquito production in order to address the potential for transmission of disease in humans, livestock, domestic animals, and wildlife. The larvicides currently used include materials not known to adversely impact septic system

bacteria: *Bacillus sphaericus* as an active ingredient (e.g., VectoLex), methoprene, (e.g., Altosid briquets), larvicide oils (e.g., BVA 2 and CocoBear), and monomolecular films (e.g., Agnique MMF). A larvicide oil or monomolecular film must be used if mosquito larvae are in the pupal phase. These products are selected for these special physical conditions as they are not known to impact the subsurface resident bacterial mats that are associated with septic system leach fields. However, because numerous household chemical products are known to adversely impact the septic bacteria (USEPA 2015; Ecodrain 2015; National Pesticide Information Center 2015), a remote chance may exist that septic system bacteria could be impacted by some methoprene-based products.

Although no published information is available about the potential toxicity of some currently used methoprene-based products (e.g., Vectolex, Altosid briquets) to septic system bacterial populations (USEPA 2001; Schooley et al. 1975), applications of these products near the septic system should not be a problem. Based on currently available information, and using appropriate District BMP techniques, methoprene should be an acceptable larvicide to treat mosquitoes associated with private septic systems. The District can revisit its use of methoprene for malfunctioning or improperly sealed septic systems if and when additional studies are conducted and published. Meanwhile, the District will rely as much as possible on the other methods of mosquito larvae control and insist that property owners resolve the problems with their private systems, i.e., keeping the tanks impervious to mosquito entry and the leach field operating properly without water rising to the ground surface to stagnate. With the exception of some limitations on the direct application of methoprene-based products to the septic tank, the fate and transport of these larvicides is generally similar to the characteristics of fate and transport to soils and water under the other approved applications (see Sections 9.2.7.1.1 and 9.2.7.1.2).

9.2.7.1.1 Biological Agents

Bacillus sphaericus is a bacterial larvicide that is applied to sources of mosquito production, such as irrigation ditches, floodwater, standing ponds, woodland pools, pastures, tidal water, fresh- or saltwater marshes, and stormwater retention areas. It damages and paralyzes the gut of mosquito larvae that ingest the spores. Although dormant Bs spores may persist in the environment for several weeks to months and the δ-endotoxins generally persist for 2 to 4 weeks following application, the δ-endotoxins degrade rapidly in sunlight and are degraded by soil microorganisms. Bs does not percolate through the soil and readily binds to sediments. It is highly selective for mosquitoes and is not toxic to nontarget species, including birds, mammals, fish, and invertebrates in amounts that effectively control mosquito larvae. For these reasons, Bs should result in minimal, if any, adverse effects to surface water or groundwater.

Bti is applied in a similar manner and often in combination with Bs. Bti toxins may persist in soil for several months, yet a half-life for typical Bti products on foliage is approximately 1 to 4 days due to rapid degradation in sunlight. Toxicity is minimal to nonexistent to nontarget avian, freshwater fish, freshwater aquatic invertebrates, estuarine and marine animals, arthropod predators/parasites, honeybees, annelids, and mammalian wildlife at the label use rates of registered Bti active ingredients. For these reasons, Bti should result in minimal, if any, adverse effects to surface water or groundwater.

Spinosad is a biologically derived insecticide produced from the fermentation of *Saacharopolyspora spinosa*, a naturally occurring soil organism. It activates the central nervous system of insects through interaction with neuroreceptors and causes mortality through continuous stimulation of the insect nervous system. Spinosad degrades quickly in sunlight in both aqueous and soil environments. It adsorbs strongly to soil particles where it is quickly metabolized by soil microorganisms under aerobic conditions and is therefore unlikely to leach into groundwater. Spinosad is practically nontoxic to birds and mammals but is slightly to moderately toxic to fish and most aquatic invertebrates. However, low amounts typically used for mosquito control would not likely pose a significant risk to potential ecological receptors. For these reasons, spinosad should result in minimal, if any, adverse effects to surface water or groundwater.

The District will apply all biological agent larvicides following District BMPs and in strict conformance with their PAP and the label requirements, which have been approved by CDPR for use in California. Proper application of methods using District BMPs will minimize adverse effects and substantially avoid degradation of water quality. Therefore, the use of these larvicides would have a less-than-significant impact to surface and groundwater resources.

> **Impact WR-11:** Application of the biological agents Bs, Bti, and spinosad would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.

9.2.7.1.2 Hydrocarbon Esters

Methoprene is an insect growth regulator that is applied at very low concentrations for mosquito control in the form of briquettes, pellets, granules, and liquid. It consists of two enantiomers: S-methoprene and R-methoprene, with S-methoprene being the biologically active enantiomer. Fate and transport characteristics of the s-enantiomer and the mixture are similar, but toxicity differs. Methoprene readily binds to suspended solids in the water column and soils. It rapidly degrades by photolysis and is metabolized in soil under both aerobic and anaerobic conditions. Although it may exhibit toxicity to fish and aquatic invertebrates (generally at higher concentrations and application rates than used for mosquito control), as well as nontarget insects including moths, butterflies, and beetles, methoprene is considered the least toxic of all larvicide alternatives especially at concentrations allowed for mosquito control.

These products would have a less-than-significant impact to surface or groundwater resources, including the limited use near septic systems, when applied following District BMPs and used in accordance with the recommended BMP application techniques described in their PAP and product label requirements.

> **Impact WR-12:** Application of methoprene would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.

9.2.7.1.3 Surfactants

The monomolecular film used in California for the control of mosquito larvae is alpha-isooctadecyl-omega-hydroxypoly (oxyethylene). Monomolecular films spread a thin film on the surface of the water that makes it difficult for mosquito larvae, pupae, and emerging adults to attach to the water's surface, causing them to drown. It also disrupts larval respiration. Reported half-lives of monomolecular films in water range from 5 to 22 days. It may temporarily impact nontarget surface-breathing insects but has no observable effects to amphibians, fish, or other aquatic organisms. These products should not result in adverse water quality conditions in surface water or groundwater when used in accordance with approved BMP application requirements and techniques.

Specially derived aliphatic solvents (e.g., mineral oils and aliphatic petroleum hydrocarbons) are used to form a coating on top of water to drown larvae, pupae, and emerging adult mosquitoes. Petroleum distillates can be more effective than monomolecular films but break down much more rapidly (2 to 3 days). They have low water solubility and high sorption to organic matter. They are practically nontoxic to most nontarget organisms. Using District BMP application techniques, these products should result in minimal, if any, adverse effects to water quality conditions in surface water or groundwater.

The District will avoid use of surfactants, when possible, in sites with aquatic nontarget species or natural enemies of mosquitoes present such as nymphal damselflies and dragonflies, dytiscids, hydrophilids, corixids, notonectids, and ephydrids. Although surfactants can be used with pupae, microbial larvicides (e.g., Bti, Bs) or insect growth regulators (e.g., methoprene) are often used with other earlier life stages (BMP H2) to prevent development of pupae and minimize use of surfactants.

The District will apply all surfactant larvicides following District BMPs and in strict conformance with their PAP and the label requirements, which have been approved by CDPR for use in California. Proper application using District BMPs will minimize adverse effects and substantially avoid degradation of water

quality. Therefore, the use of these chemicals would have a less-than-significant impact to surface water or groundwater resources.

> **Impact WR-13:** Application of the surfactant larvicides oxyethylene, mineral oils, and aliphatic petroleum hydrocarbons would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.

9.2.7.2 Mosquito Adulticides

The use of adulticides to control mosquitoes is the method of control in the bottom tier of the District's IVM program. Adulticides are only applied when other tools are not available or applicable and when specific criteria are met, including species composition, population density, proximity to human populations, and/or human disease risk. The active ingredients currently in use have been deliberately selected for lack of persistence and minimal effects on nontarget organisms when applied in strict conformance to label instructions for ULV mosquito control. Adulticides are applied following District BMPs, using ground application equipment or applied in the future using rotary and/or fixed wing aircraft, and used in strict conformance with label requirements and the District's PAP.

In the special circumstance of septic tanks/onsite wastewater treatment systems, and at the request for service from District clients, the District inspects for the presence of larval and/or adult mosquitoes. Mosquito populations may also be detected via adult mosquito surveillance in a given area (e.g., adult mosquito traps). The District staff may observe surface water in the vicinity of a failed septic tank. In these situations, the District may provide selected mosquito adulticide treatment to the environs of the tank and/or the septic leach system. The adulticides currently used for malfunctioning or improperly sealed septic systems include MGK Pyrocide 7067 (pyrethrin), Zenivex E20 (etofenprox), or Merus 2.0 (pyrethrin) (National Pesticide Information Center 2014). Adulticides are often applied in a focused process to selected areas contiguous to the septic tank/system. Adult mosquito control performed in relation to mosquito production from septic systems is typically site specific, and the adulticide is applied with handheld equipment (e.g., handheld ULV fogger, ULV backpack fogger). However, if the potential for transmission of disease by mosquitos associated with septic systems appears to be problematic, the District may, in that instance, prudently use more aggressive approaches such as truck-mounted applications. In these situations the District would use proven BMP techniques aligned with these applications to reduce or minimize any nontarget impacts.

Because numerous household chemical products are known to adversely impact the septic bacteria (Ecodrain 2015), a remote chance may exist that septic system bacteria could be impacted by some pyrethrin products (National Pesticide Information Center 2014; USEPA 2006c). To alleviate this concern, the applications would be conducted using strict BMP techniques and would generally not be introduced directly into the tank. The District can revisit its use of pyrethrin products for septic systems when additional studies are conducted and published. Meanwhile, the District will rely as much as possible on the other methods of control and insist that property owners resolve the problems with their private systems. With the exception of some limitations on the direct application of pyrethrin-based products to the septic tank, the fate and transport of these adulticides is generally similar to the characteristics of fate and transport to soils and water under other approved applications. Typical applications to standing water above the leach field would not likely result in transport or leaching to the biological bacterial mat in the leach lines because they adsorb strongly to soil surfaces, and are generally considered immobile in soils and, therefore, are unlikely to leach to groundwater (USEPA 2006c). Although special conditions are associated with the septic applications, the fate and transport of these adulticides when used in areas associated with septic systems are generally similar to those of other application scenarios (see Section 9.2.7.2.1).

9.2.7.2.1 Pyrethrins and Pyrethroids

The District uses pyrethrins and pyrethroids to control adult mosquitoes and yellow jacket wasps. Pyrethrins are naturally occurring products distilled from the flowers of Chrysanthemum species. Pyrethroids are

synthetic compounds that are chemically similar to the pyrethrins, but have been modified to increase their stability and activity against insects, while minimizing their effect on nontarget organisms. First generation or "Type I" photosensitive pyrethroids include d-allethrin, phenothrin (sumithrin), prallethrin, resmethrin, and tetramethrin. Typically, these pyrethroids are used indoors and around residential areas. The newer second-generation pyrethroids are mostly "Type II" pyrethroids. The active ingredients that fall into this group include deltamethrin esfenvalerate, and permethrin. Type II pyrethroids are more toxic than Type I pyrethroids because they are less photosensitive and persist longer in the environment. Etofenprox is a synthetic pyrethroid-like chemical, differing in structure from pyrethroids in that it lacks a carbonyl group and has an ether moiety, whereas pyrethroids contain ester moieties. Pyrethrins and pyrethroids act by causing a persistent activation of the sodium channels on insect neurons.

Pyrethrins and pyrethroids quickly adsorb to suspended solids in the water column and partition into the sediment. They adsorb strongly to soil surfaces, and are generally considered immobile in soils and, therefore, are unlikely to leach to groundwater (USEPA 2006c). These materials are relatively nontoxic to mammals and birds, but are highly toxic to fish and invertebrates. The major route of degradation is through photolysis in both water and soil. Pyrethrins and pyrethroids may be persistent in environments free of light, and pyrethroids as a class have been implicated in 303(d) listings of sediment toxicity in urban creeks (BASMAA 2013). However, the ULV applications common to mosquito control and the limited use at ground-dwelling yellow jacket wasp nests (that pose an imminent threat to people or to pets) encourage dissipation rather than persistence in the environment.

Insecticides containing pyrethrins and pyrethroids usually also contain PBO as a synergist. PBO interferes with the insect's ability to detoxify pyrethrins and pyrethroids, thus enhancing the product's effectiveness. PBO has low toxicity to mammals but is a possible endocrine disruptor and is included in the final list of chemicals for screening under USEPA's Endocrine Disruptor Screening Program. It is moderately to highly toxic to fish and is highly toxic to aquatic invertebrates. PBO is moderately mobile in soil and water but degrades rapidly in the environment by photolysis and through metabolism by soil microbes. Although it degrades rapidly, release of PBO to the environment may "activate" persistent pyrethroids that are already present in the sediment. However, PBO would have a less-than-significant impact on surface water or groundwater when applied following District BMPs and using ULV techniques, and when used in strict conformance with label requirements and the District's PAP.

> **Impact WR-14:** Application of the synergist PBO would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.

The District applies pyrethrins in terrestrial and aquatic environments for adult mosquito control using ULV techniques. They are also used locally to treat ground-dwelling yellow jacket wasp nests. Pyrethrins quickly adsorb to suspended solids in the water column and adsorb strongly to soil surfaces making them immobile in soils and unlikely to leach into groundwater. They degrade via photolysis and are likely to persist under anaerobic conditions. Pyrethrins have low to moderate acute toxicity to mammals but are practically nontoxic to birds. They are very highly toxic to freshwater fish and invertebrates. Several studies have shown that pyrethrins applied using ULV techniques do not accumulate in water or sediment following repeated applications. These studies also determined that no toxicity is associated when exposure is limited to the amounts used when following ULV protocols for mosquito control (Lawler et al. 2008; Amweg et al. 2006). Pyrethrins would have a less-than-significant impact on surface water or groundwater, including their limited use near septic systems, when applied following District BMPs and using ULV techniques, and when used in accordance with label requirements and the District's PAP.

> **Impact WR-15:** Application of pyrethrins would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.

Allethrins (d-*trans* isomer) are Type I synthetic pyrethroids that are usually combined with synergists such as PBO. They are typically applied as an aerosol to yellow jacket wasp ground nests. Any material that gets into the air is rapidly degraded by photolysis in less than 8 hours. The toxicity of allethrin varies

depending on which of its four isomers are present. Allethrins are highly toxic to fish and invertebrates but degrade too quickly to result in substantial adverse effects to surface or groundwater when applied following District BMPs and used in accordance with label and PAP requirements. Use of allethrins would have a less-than-significant impact on surface water or groundwater.

> **Impact WR-16:** Application of allethrins would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.

Permethrin is a Type I synthetic pyrethroid that is usually combined with synergists such as PBO to control adult mosquitoes using ULV techniques and for yellow jacket wasp control. It is hydrophobic and tends to partition to soil and sediment. Its primary degradation pathways include photolysis and aerobic metabolism and it may be persistent in environments free of light. Permethrin is slightly toxic to humans and has been included in the final list of chemicals for screening under USEPA's Endocrine Disruptor Screening Program. It has low toxicity to mammals and is practically nontoxic to birds, but is very highly toxic to fish, aquatic invertebrates, and honeybees.

Permethrin formulations are applied following District BMPs and used in strict conformance with label requirements such as aquatic habitat buffer zones. Permethrin has a strong repellent effect in the environment, which reduces toxic effects to bees under field conditions (Appendix B). Pesticides that could affect insect pollinators will not be applied in liquid or spray/fog forms over large areas (more than 0.25 acre) during the day when honeybees are present and active or when other pollinators are active (BMP H12). When applied in accordance with ULV label instructions, studies have shown rapid dissipation, low persistence, and no observed aquatic fish and invertebrate toxicity following aerial ULV applications (Appendix B). Although one study found higher levels of permethrin on the surface microlayer of the waterbody, corresponding water samples did not contain detected residues, and higher surface microlayer concentrations were not correlated with toxic effects in the waterbody. When applied directly to ground nests of yellow jacket wasps or around residences or parks for tick abatement, the product is used with careful techniques such as controlled applications to very small, localized areas.

Permethrin use is restricted to situations when it is absolutely necessary and in ULV applications that are designed to have the ingredients degrade rapidly and, thus, reduce the potential for impacts to nontarget ecological receptors. When District BMPs are implemented and when materials are applied according to the District's PAP using ULV techniques, the application of permethrin would have a less-than-significant impact on surface water or groundwater, including locations where receiving waters are 303(d) listed for pyrethroids or sediment toxicity because of the study results reported above (from Appendix B).

> **Impact WR-17:** Application of permethrin would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.

Phenothrin (or sumithrin) is a Type I synthetic pyrethroid that is usually combined with synergists such as PBO to control adult mosquitoes and yellow jacket wasps. Phenothrin has low solubility and a relatively high affinity for binding to soil. It degrades through photolysis in water and aerobic metabolism in soil but is moderately persistent under aerobic conditions and persistent under anaerobic conditions. Phenothrin is not toxic to mammals or birds but is highly toxic to fish and freshwater invertebrates. When applied locally (for yellow jacket wasp control) or in ULV applications (for mosquito control) following District BMPs and used in accordance with label requirements and the District's PAP, phenothrin would not result in substantial adverse effects to surface water or groundwater. Use of phenothrin would have a less-than-significant impact on surface water or groundwater.

> **Impact WR-18:** Application of phenothrin would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.

Prallethrin is a Type I synthetic pyrethroid. The only prallethrin-containing product registered for mosquito control in California is Duet, which also contains phenothrin and PBO. Prallethrin is also intermittently used to target yellow jacket wasp nests. Prallethrin readily sorbs to soils and sediments and degrades

quickly via photolysis in both water and soil. It is not toxic to mammals or birds but is highly toxic to fish and nontarget aquatic invertebrates. When applied locally (for yellow jacket wasp control) or in ULV applications (for mosquito control) following District BMPs and used in accordance with label requirements and the District's PAP, prallethrin would not result in substantial adverse effects to surface water or groundwater. Use of prallethrin would have a less-than-significant impact on surface water or groundwater.

> **Impact WR-19:** Application of prallethrin would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.

Resmethrin is a Type I synthetic pyrethroid that is usually combined with synergists such as PBO to control adult mosquitoes in tree holes and using ULV techniques. Resmethrin has a high affinity to bind to soils, sediments, and organic carbon and it degrades rapidly when exposed to light. When not subject to photolysis, it may be environmentally persistent. Resmethrin has low toxicity to mammals but has been included in the final list of chemicals for screening under USEPA's Endocrine Disruptor Screening Program. It is moderately toxic to birds and highly toxic to fish and aquatic invertebrates.

Despite its relatively high toxicity and potential for persistence, studies have shown rapid dissipation, low persistence, and no observed aquatic fish and invertebrate toxicity following aerial ULV application (Appendix B). When District BMPs are implemented and materials are applied according to the District's PAP using ULV techniques, the application of resmethrin would have a less-than-significant impact on surface water or groundwater.

> **Impact WR-20:** Application of resmethrin would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.

Tetramethrin is a Type I synthetic pyrethroid that the District may use in the future in very localized applications for the control of yellow jacket wasps. It is slightly mobile in soil but decomposes rapidly by photolysis and hydrolysis and is not considered persistent in the environment. Tetramethrin is practically nontoxic to birds and terrestrial mammals but meets the criteria for classification as a possible human carcinogen. It is highly toxic to fish, aquatic invertebrates, and honeybees. When applied following District BMPs and used according to label requirements and BMP application techniques that limit its release to aquatic systems, tetramethrin would not result in substantial adverse effects to surface water or groundwater. Use of tetramethrin would have a less–than-significant impact on surface water or groundwater.

> **Impact WR-21:** Application of tetramethrin would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.

Deltamethrin is a longer lasting Type II synthetic pyrethroid that kills adult mosquitoes, yellow jacket wasps, and ticks on contact and through ingestion. It may be used in the future and applied directly to yellow jack wasp nest openings or used for localized tick control. Deltamethrin is low to moderately toxic to humans and may cause prenatal damage. It is practically nontoxic to birds but is very highly toxic to fish and nontarget aquatic invertebrates. For this reason, it is not used in aquatic environments. It binds to soils and sediments and may be persistent in the environment. When applied locally to target yellow jacket wasp nests following District BMPs, deltamethrin would not result in substantial adverse effects to surface water or groundwater. Use of deltamethrin would have a less-than-significant impact on surface water or groundwater.

> **Impact WR-22:** Application of deltamethrin would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.

Esfenvalerate is a relatively new Type II synthetic pyrethroid that is deployed above ground in bait stations for yellow jacket wasp control. It is practically insoluble in water and has a strong tendency to bind to sediments and soil. It degrades via photolysis and aerobic metabolism and does not appear to persist in the environment. Esfenvalerate is considered moderately toxic to mammals and birds, highly

toxic to fish, aquatic invertebrates, and honeybees, and is bioaccumulative in fish. Additionally, esfenvalerate has been included in the final list of chemicals for screening under USEPA's Endocrine Disruptor Screening Program. However, when applied following District BMPs and used according to label guidelines and BMP application techniques that limit its release to the soil surface and aquatic systems, esfenvalerate should not result in substantial adverse effects to surface water or groundwater. Use of esfenvalerate would have a less-than-significant impact on surface water or groundwater.

> **Impact WR-23** Application of esfenvalerate would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.

Etofenprox is a pyrethroid-like insecticide that is used as a mosquito adulticide and is available in formulations that do not contain PBO. It is virtually insoluble in water and stable to hydrolysis but is rapidly degraded by photolysis. Residues of etofenprox are not likely to persist in the environment. It has low toxicity to mammals but is highly toxic to fish and aquatic invertebrates. Based on toxicity and environmental fate, etofenprox would not result in substantial adverse effects to surface water or groundwater when applied following District BMPs and used in accordance with label requirements and the District's PAP. Use of etofenprox would have a less-than-significant impact on surface water or groundwater.

> **Impact WR-24:** Application of etofenprox would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.

9.2.7.3 Yellow Jacket Wasp and Tick Abatement

Pyrethrins and pyrethroids are applied directly to yellow jack wasp nest openings and may be used for localized tick control in the future. The active ingredients the District uses are described under Mosquito Adulticides (Section 9.2.7.2).

9.2.8 Other Nonchemical Control/Trapping Alternative

This alternative includes the trapping of rodents and/or yellow jacket wasps that pose a threat to public health and welfare. For both species, tamper-resistant or baited traps are used, which limits the exposure of chemical-containing baits to the environment. This alternative would have no impact to surface water or groundwater.

> **Impact WR-25:** The Nonchemical Control/Trapping Alternative collection techniques use tamper-resistant or baited traps, which limit the exposure of chemical-containing baits to the environment **no impact** would occur to surface water or groundwater.

9.2.9 Cumulative Impacts

Cumulative impacts to water resources are discussed in Section 13.7. In summary, several receiving waters in the Program Area are already included on the CWA 303(d) list as impaired by pesticides, pyrethroids, or sediment toxicity, with the likely cause being the use of common household insecticides containing pyrethroids by members of the public, not vector control activities the District conducts. Where receiving waters (such as San Pablo Bay or Central San Francisco Bay) have been designated as impaired by pesticides, pyrethroids, or sediment toxicity, an existing significant cumulative impact is associated with the combined applications of these pesticides. Therefore, **the District's use of any pyrethroid is contributing in less-than-significant incremental amounts to an existing cumulatively considerable impact to water resources by all users of pyrethroids in the Program Area.** No additional impacts were identified in association with the chemical and nonchemical Program alternatives, and **no additional cumulative impacts are anticipated to occur** (i.e., the District's less-than-significant contributions are not triggering a new cumulative impact).

9.2.10 Environmental Impacts Summary

Table 9-4 provides a summary of the identified impacts for each subgroup of practices and chemicals included in the Program.

Table 9-4 Summary of Water Resources Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Effects on Water Resources						
Impact WR-1: The Surveillance Alternative would not result in increased soil erosion, so the impact to surface water would be **less than significant**. No mitigation is required.	LS	na	na	na	na	na
Impact WR-2: The Surveillance Alternative collection devices would not contact nor interact with the environment. **No impact** would occur to surface water or groundwater.	N	na	na	na	na	na
Impact WR-3: The Physical Control Alternative's activities to modify water circulation, remove sediment, and maintain water control facilities to reduce habitat conditions for mosquito production would have a **less-than-significant** impact on soil erosion and water resources and no mitigation is required.	na	LS	na	na	na	na
Impact WR-4: Mechanical removal of vegetation from aquatic habitats would have a **less-than-significant** impact to surface water and **no impact** to groundwater resources.	na	na	LS, N	na	na	na
Impact WR-5: Application of the herbicides imazapyr and glyphosate would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	LS	na	na	na
Impact WR-6: Application of the herbicide triclopyr would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	LS	na	na	na
Impact WR-6: Application of the herbicide triclopyr would have a less-than-significant impact to **surface and groundwater** resources and no mitigation is required.	na	na	LS	na	na	na
Impact WR-8: Application of modified plant oils and lecithins would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	LS	na	na	na

Table 9-4 Summary of Water Resources Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact WR-9: The Biological Control Alternative's use of mosquitofish limits wastewater discharges to the sanitary sewer or upland areas. Therefore, the use of mosquitofish would have a **less-than-significant** impact on surface and groundwater resources and no mitigation is required.	na	na	na	LS	na	na
Impact WR-10: The Biological Control Alternative's use of mosquitofish is limited to man-made water features that are hydrologically isolated from receiving waters. Therefore, the use of mosquitofish would have a **less-than-significant** impact on surface and groundwater resources and no mitigation is required.	Na	na	na	LS	na	na
Impact WR-11: Application of the biological agents Bs, Bti, and spinosad would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-12: Application of methoprene would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-13: Application of the surfactant larvicides oxyethylene, mineral oils, and aliphatic petroleum hydrocarbons would have a **less-than-significant** impact **to** surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-14: Application of the synergist PBO would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-15: Application of pyrethrins would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-16: Application of allethrins would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-17: Application of permethrin would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na

Table 9-4 Summary of Water Resources Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact WR-18: Application of phenothrin would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-19: Application of prallethrin would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-20: Application of resmethrin would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-21: Application of tetramethrin would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-22: Application of deltamethrin would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-23 Application of esfenvalerate would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-24: Application of etofenprox would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-25: The Nonchemical Control/Trapping Alternative collection techniques use tamper-resistant or baited traps, which limit the exposure of chemical-containing baits to the environment **no impact** would occur to surface water or groundwater.	na	na	na	na	na	N

LS = Less-than-significant impact
N = No impact
na = Not applicable
SM = Potentially significant but mitigable impact
SU = Significant and unavoidable impact

9.2.11 Mitigation and Monitoring

The District implements product label requirements and District BMPs to avoid or otherwise minimize and reduce potential adverse effects to surface and groundwater resources from the applied chemicals during and following pesticide applications. The District applies all chemicals in strict conformance with label requirements that have been approved by CDPR for use in California, including restrictions on application rates and methods, storage, transportation, mixing, and container disposal. As applicable, insecticides are applied in conformance with the PAP, as required by the Vector Control Permit, and herbicide formulations will be applied in conformance with the APAP, as required by the Aquatic Weed Control Permit. The District also implements hazardous materials and spill management control measures to prevent and reduce potential exposure of spilled chemicals to surface and groundwater resources.

Because all impacts to water resources are less than significant, no mitigation is required. However, the District will continue surveillance and monitoring on a routine basis. Sites are monitored post-treatment to determine if the target vector or weeds were effectively controlled with minimum effect to the environment and nontarget organisms. This information is used to help design future treatment methods in the same season or future years to respond to changes in site conditions.

10 Air Quality

This chapter is based on Appendix C, *Air Quality and Greenhouse Gas Emissions Technical Report*. It presents the environmental setting for the Marin/Sonoma Mosquito Vector Control District's (MSMVCD; the District) Proposed Program, an analysis of environmental impacts to air quality in the District's Program Area, and mitigation measures for a potentially significant impact. This chapter evaluates Program emissions to determine individual and combined effects in relation to established thresholds of significance. The Proposed Program is the continuation of strategies (alternatives) currently employed for mosquito and/or vector control.

10.1 Environmental Setting

State and federal law defines criteria emissions to include the following: reactive organic gases or volatile organic compounds (ROGs or VOCs), nitrogen oxides (NO_X, as nitric oxide [NO] and nitrogen dioxide [NO_2]), carbon monoxide (CO), sulfur dioxide (SO_2), respirable particulate matter (PM_{10}), and fine particulate matter ($PM_{2.5}$). Of these, ROGs and NO_X are precursors to ground-level photochemical ozone (O_3) formation. Elimination of tetraethyl lead in motor gasoline has eliminated lead (Pb) emissions from vehicles and portable equipment, although tetraethyl lead is still used in some types of aviation gasoline.

During applicable mosquito and/or vector control activities, the Program would generate criteria emissions primarily from the combustion of fossil fuels (i.e., gasoline, diesel, jet fuel) used to operate portable equipment, vehicles, and aircraft across the District's Service Area and to a minor extent from chemical treatment applications. (Control activities would also cause greenhouse gas emissions, which are addressed in Chapter 11.)

10.1.1 Program Location

The aggregated Program Area comprises Marin and Sonoma counties for the District's Service Area, and the adjacent counties where control activities may be provided upon request: Yolo, Solano, Lake, and Mendocino. These counties are predominantly in the San Francisco Bay Area Air Basin (SFBAAB), under the jurisdiction of the Bay Area Air Quality Management District (BAAQMD), along with the Northern Sonoma County Air Pollution Control District (NSCAPCD), the Yolo-Solano Air Quality Management District (YSAQMD), the Lake County Air Quality Management District (LCAQMD), and the Mendocino County Air Quality Management District (MCAQMD). The bulk of criteria pollutant emissions resulting from Program activities would occur in the San Francisco Bay Area, and minor amounts would occur in northern Sonoma, Yolo, and Solano counties. The bulk of mosquito and vector control activity emissions would occur in the Bay Area portion of MSMVCD's Service Area (i.e., Marin and Sonoma counties), and only minor amounts would occur in Yolo, Solano, Lake, and Mendocino counties.

Air districts in California are required to monitor air pollutant levels to assure that National Ambient Air Quality Standards (NAAQS) and California Ambient Air Quality Standards (CAAQS) are met and, in the event that they are not, to develop strategies to meet these standards. If the standards are met, the local air basin is classified as being in "attainment;" if the standards are exceeded, it is classified as "nonattainment." Where insufficient data exist to make a determination, an area is deemed "unclassified."

The SFBAAB is designated as nonattainment for the state 1-hour, state 8-hour, and federal 8-hour O_3 standards, and nonattainment for all state PM_{10} and $PM_{2.5}$ standards. The SFBAAB is also designated unclassified for the 24-hour federal PM_{10} standard, and nonattainment and attainment for the federal 24-hour and annual $PM_{2.5}$ standards, respectively. For all other pollutants and standards, the SFBAAB is designated as either attainment or unclassified status (BAAQMD 2014; CARB 2013a; USEPA 2013c; see Table 10-2).

Northern Sonoma County is designated attainment for the state 1-hour O_3 standard and unclassified/attainment for the state and federal 8-hour O_3 standards. Yolo-Solano counties are "Serious" nonattainment for the state 1-hour O_3 standard, nonattainment for the state and federal 8-hour O_3 standards, nonattainment for the state 24-hour and annual PM_{10} standards, and partial nonattainment for the federal 24-hour $PM_{2.5}$ standard. Mendocino County is designated nonattainment for the state 24-hour and annual PM_{10} standards. For all other pollutants and standards Mendocino, northern Sonoma, and Yolo-Solano counties are designated either attainment or unclassified status, and Lake County is entirely in attainment or unclassified for all pollutants (CARB 2013a; USEPA 2013c; YSAQMD 2013; MCAQMD 2005).

10.1.2 Meteorology and Climate

The Program Area climate is characterized by moderately wet winters and dry summers. For the region including the MSMVCD, about 90 percent of the annual total rainfall is received in the November through April period. Between June and September, normal rainfall is typically less than 0.6 inch (1.5 centimeters). Temperatures in the Program Area average about 60 degrees Fahrenheit (°F) (15 degrees Celsius [°C]) annually, with average summer highs in the 70 to 80°F (21 to 27°C) range and average winter lows in the 40 to 50°F (4 to 10°C) range. Precipitation averages about 23 inches (58 centimeters) per year, although annual precipitation can vary significantly from year-to-year. Annual average wind speeds in the Program Area are about 8 miles per hour (3.6 meters per second). The predominant direction of air pollution transport in the Program Area is inland from the coastal areas (BAAQMD 2010a; World Climate 2012; NOAA 2008).

10.1.3 Criteria Air Pollutants and Potential Health Impacts

A criteria or regulated air pollutant is any air pollutant for which ambient air quality standards have been set by the USEPA or the California Air Resources Board (CARB). Primary air quality standards are established to protect human (public) health. Secondary air quality standards are designed to protect public welfare from effects such as diminished production and quality of agricultural crops, reduced visibility, degraded soils, materials and infrastructure damage, and damaged vegetation. Criteria pollutants include O_3, NO_2, CO, SO_2, PM_{10}, and $PM_{2.5}$. The six most prevalent criteria pollutants and their potential health effects are described below.

10.1.3.1 Ozone

Ground-level O_3 is a secondary pollutant formed in the atmosphere by a series of complex chemical reactions and transformations in the presence of sunlight above urban areas due to the mixing effects of temperature inversions. Nitrogen oxides (NO_X) and reactive organic gases (ROGs)[1] are the principal constituents in these reactions. NO_X and ROG emissions are predominantly attributed to mobile sources (onroad motor vehicles and other mobile sources). Thus, regulation and control of NO_X and ROGs from these sources is essential to reduce the formation of ground-level O_3.

O_3 is a strong irritating gas that can chemically burn and cause narrowing of airways, forcing the lungs and heart to work harder to provide oxygen to the body. A powerful oxidant, O_3 is capable of destroying organic matter, including human lung and airway tissue; it essentially burns through cell walls. O_3 damages cells in the lungs, making the passages inflamed and swollen. O_3 also causes shortness of breath, nasal congestion, coughing, eye irritation, sore throat, headache, chest discomfort, breathing pain, throat dryness, wheezing, fatigue, and nausea. It can damage alveoli, the individual air sacs in the lungs where oxygen and carbon dioxide are exchanged. O_3 has been associated with a decrease in resistance to infections. People most likely to be affected by O_3 include the elderly, the young, and athletes. O_3 may pose its worst health threat to people who already suffer from respiratory diseases such as asthma, emphysema, and chronic bronchitis (VCAPCD 2003).

[1] Also referred to as reactive organic compounds (ROCs) or VOCs.

10.1.3.2 Nitrogen Dioxide

NO_2 is formed in the atmosphere primarily by the rapid reaction of the colorless gas NO with atmospheric oxygen. It is a reddish brown gas with an odor similar to that of bleach. NO_2 participates in the photochemical reactions that result in O_3. The greatest source of NO, and subsequently NO_2, is the high-temperature combustion of fossil fuels such as in motor vehicle engines and power plant boilers. NO_2 and NO are referred to collectively as NO_X. NO_2 can irritate and damage the lungs, cause bronchitis and pneumonia, and lower resistance to respiratory infections such as influenza. Researchers have identified harmful effects, similar to those caused by O_3, with progressive changes over 4 hours of exposure causing impaired pulmonary function, increased incidence of acute respiratory disease, and difficult breathing for both bronchitis sufferers and healthy persons (VCAPCD 2003).

10.1.3.3 Carbon Monoxide

CO is a common, colorless, odorless, highly toxic gas. It is produced by natural and anthropogenic (caused by human activity) combustion processes. The major source of CO in urban areas is incomplete combustion of carbon-containing fuels (primarily gasoline, diesel fuel, and natural gas). However, it also results from combustion processes including forest fires and agricultural burning. Ambient CO concentrations are generally higher in the winter, usually on cold, clear days and nights with little or no wind. Low wind speeds inhibit horizontal dispersion, and surface inversions inhibit vertical mixing. Traffic-congested intersections have the potential to result in localized high CO levels.

When inhaled, CO does not directly harm the lungs. The impact from CO is on oxygenation of the entire body. CO combines chemically with hemoglobin, the oxygen-transporting component of blood, which diminishes the ability of blood to carry oxygen to the brain, heart, and other vital organs. Red blood cells have 220 times the attraction for CO as for oxygen. This affinity interferes with movement of oxygen to the body's tissues. Effects from CO exposure include headaches, nausea, and death. People with heart ailments are at risk from low-level exposure to CO. Also sensitive are people with chronic respiratory disease, the elderly, infants and fetuses, and people suffering from anemia and other conditions that affect the oxygen-carrying capacity of blood. High CO levels in a concentrated area can result in asphyxiation. Studies show a synergistic effect when CO and O_3 are combined (VCAPCD 2003).

10.1.3.4 Sulfur Dioxide

SO_2 is a colorless gas with a sharp, irritating odor. It can react in the atmosphere to produce sulfuric acid and sulfates, which contribute to acid deposition and atmospheric visibility reduction. It also contributes to the formation of PM_{10}. Most of the SO_2 emitted into the atmosphere is from burning sulfur-containing fossil fuels by mobile sources such as marine vessels and farm equipment and stationary fuel combustion. SO_2 irritates the mucous membranes of the eyes and nose and may also affect the mouth, trachea, and lungs. Healthy people may experience sore throats, coughing, and breathing difficulties when exposed to high concentrations. SO_2 causes constriction of the airways and poses a health hazard to asthmatics, which are very sensitive to SO_2. Children often experience more respiratory tract infections when they are exposed to SO_2 (VCAPCD 2003).

10.1.3.5 Respirable Particulate Matter, 10 Microns

PM_{10} consists of particulate matter, fine dusts and aerosols, 10 microns or smaller in diameter. When inhaled, particles larger than 10 microns generally are caught in the nose and throat and do not enter the lungs. PM_{10} can enter the large upper branches of the lungs just below the throat, where they are caught and removed (by coughing, spitting, or swallowing).

The primary sources of PM_{10} include dust from paved and unpaved roads and construction and demolition operations. Lesser sources of PM_{10} include wind erosion, agricultural operations, residential wood combustion, smoke, tailpipe emissions, and industrial sources. These sources have different constituents, and, therefore, varying effects on health. Road dust is composed of many particles other

than soil dust. It also includes engine exhaust, tire rubber, oil, and truckload spills. Diesel particulate matter (DPM) contains many toxic particle and elemental carbon (soot), and is considered a toxic air contaminant in California. Airborne particles absorb and adsorb toxic substances and can be inhaled and lodge in the lungs. Once in the lungs, the toxic substances can be absorbed into the bloodstream and carried throughout the body. PM_{10} concentrations tend to be lower during the winter months because weather greatly affects PM_{10} concentrations. During rain, concentrations are relatively low, and on windy days, PM_{10} levels can be high. Photochemical aerosols, formed by chemical reactions with man-made emissions, may also influence PM_{10} concentrations.

Elevated ambient particulate levels are associated with premature death, an increased number of asthma attacks, reduced lung function, aggravation of bronchitis, respiratory disease, cancer, and other serious health effects. Short-term exposure to particulates can lead to coughing, minor throat irritation, and a reduction in lung function. Long-term exposure can be more harmful. The USEPA estimates that 8 percent of urban nonsmoker lung cancer risk is due to PM_{10} in soot from diesel trucks, buses, and cars. Additional studies by the USEPA and the Harvard School of Public Health estimate that 50,000 to 60,000 deaths per year in the US are caused by particulates. PM_{10} particles collect in the upper portion of the respiratory system, affecting the bronchial tubes, nose, and throat. They contribute to aggravation of asthma, premature death, increased number of asthma attacks, bronchitis, reduced lung function, respiratory disease, aggravation of respiratory and cardiovascular disease, alteration of lung tissue and structure, changes in respiratory defense mechanisms, and cancer (VCAPCD 2003).

10.1.3.6 Fine Particulate Matter, 2.5 Microns

$PM_{2.5}$ is a mixture of particulate matter, fine dusts, and aerosols 2.5 microns or smaller in aerodynamic diameter. $PM_{2.5}$ can enter the deepest portions of the lungs where gas exchange occurs between the air and the blood stream. They are the most dangerous particles because the lungs have no efficient mechanisms for removing them. If these particles are soluble in water, they pass directly into the blood stream within minutes. If they are not soluble in water, they are retained deep in the lungs and can remain there permanently. This tendency increases the risks of long-term disease including chronic respiratory disease, cancer, and increased and premature death. Other effects include increased respiratory stress and disease, decreased lung function, alterations in lung tissue and structure, and alterations in respiratory tract defense mechanisms.

$PM_{2.5}$ particles are emitted from activities such as industrial and residential combustion processes, wood burning, and from diesel- and gasoline-powered vehicles. They are also formed in the atmosphere from gases such as SO_2, NO_X, ammonia, and VOCs that are emitted from combustion activities and then become particles as a result of chemical transformations in the air (secondary particles) (VCAPCD 2003).

10.1.4 Relationship of Air Pollution to Asthma

10.1.4.1 Sensitive Receptors

Consistent with the health effects of air pollution described above, certain population groups are considered more sensitive to air pollution and odors than others; in particular, children, elderly, and acutely ill and chronically ill persons, especially those with cardiorespiratory diseases such as asthma and bronchitis. Sensitive receptors (land uses) indicate locations where such individuals are typically found, namely schools, daycare centers, hospitals, convalescent homes, residences of sensitive persons, and parks with active recreational uses, such as youth sports.

Persons engaged in strenuous work or physical exercise also have increased sensitivity to poor air quality. Residential areas are considered more sensitive to air quality conditions than commercial and industrial areas, because people generally spend longer periods of time at their residences, resulting in greater exposure to ambient air quality conditions. Recreational uses such as parks are also considered

sensitive, due to the greater exposure to ambient air quality conditions and because the presence of pollution detracts from the recreational experience.

Due to the wide geographic dispersion of District activities and their short-term temporary nature at any particular location, no quantifiable risk to sensitive receptors or the general public would be posed by Program-related engine exhaust. Since the District does limited adulticiding, which typically disperses particulates in the range of 8 to 20 microns (generally larger than the ambient air quality standard range of 2.5 to 10 microns), engine exhaust is the primary source of $PM_{2.5}$ and PM_{10} emissions from Program activities.

10.1.5 Existing Air Quality

Air quality is affected by a variety of sources in the vicinity of the Program Area. Large stationary sources such as oil refineries and power plants emit substantial amounts of NO_X and ROCs, along with PM_{10} and $PM_{2.5}$. Light motor vehicles, diesel-powered construction equipment, and commercial trucks used in the Program Area are another source of these pollutants. Noncombustion sources of PM_{10} and $PM_{2.5}$ include fugitive dust from roads, construction, demolition, and earthmoving. Finally, commercial and general aviation aircraft generate emissions that affect air quality.

O_3 is a secondary pollutant that is not emitted directly by sources, but rather is formed by a reaction between NO_X and ROCs in the presence of sunlight. Reductions in O_3 concentrations are dependent upon reducing emissions of these precursors. The major sources of O_3 precursors in the Bay Area are motor vehicles and other mobile equipment (including agricultural equipment), solvent use, petroleum industry activities, nonelectric agricultural water pumping, and electric utilities operation.

BAAQMD, NSCAPCD, YSAQMD, MCAQMD, and LCAQMD operate extensive regional air monitoring networks comprised of monitoring stations (sites) that collectively measure the ambient concentrations of six criteria air pollutants: O_3, NO_2, SO_2, CO, PM_{10}, and $PM_{2.5}$. Not all monitoring stations are fully instrumented for these pollutants, while some sites have not been operating for adequate periods of time to provide representative data for characterization of attainment status.

10.1.5.1 Sources of Air Pollutants

The most significant regional sources of O_3, NO_2, and CO in ambient air are automobiles, trucks, and other onroad vehicles, along with trains, vessels, and aircraft. O_3 is not directly emitted; rather, photochemical O_3 is formed by the atmospheric reaction of VOCs and NO_X in sunlight. Gasoline and diesel engines emit VOCs and NO_X as combustion products, as does natural gas-fired equipment (stationary sources) such as pump engines, gas turbine generators, process heaters, and steam boilers.

Local PM_{10} emissions are primarily the result of fugitive dust from travel on unpaved roads, as well as construction and agricultural activities. Coarser particles also may be emitted from activities that disturb the topsoil. Other sources include wind-blown dust, pollen, salts, brake dust, and tire wear. Although $PM_{2.5}$ is a subset of PM_{10}, it differs from the rest of PM_{10}. While most of the ambient PM_{10} results from direct emissions of the pollutant, a significant amount of the ambient $PM_{2.5}$ results from transformation of precursors and condensing of gaseous pollutants in the atmosphere. Other than direct $PM_{2.5}$ emissions, the key pollutants contributing to $PM_{2.5}$ concentrations in the atmosphere are SO_2, NO_X, VOCs, and ammonia (CARB 2005).

Mobile sources used in mosquito and vector control activities include onroad fleet vehicles (light- and medium-duty trucks, vans, passenger cars), offroad ATVs, watercraft (motorboats, airboats), aircraft (helicopters and fixed-wing), portable equipment (pumps, sprayers, generators), and small equipment (handheld sprayers, foggers, dusters). Except for 2-stroke engines used in small lightweight equipment (spark ignition, 50:1 gas/oil mix), engines are 4-stroke gasoline (spark ignition) or diesel fuel (compression ignition). The dominant fuel used for these mobile sources is motor gasoline along with some diesel fuel (larger trucks), aviation gasoline (fixed-wing aircraft), and jet fuel (turbine-powered helicopters). Light

trucks, vans, and passenger cars are normally used for responding to public service requests and vector surveillance.

10.1.5.2 Volatile Organic Compounds

VOCs are present in both indoor and outdoor environments because they are necessary ingredients in industrial and consumer products such as paints, varnishes, sealers, thinners, solvents, adhesives, sealants, and some types of pesticides and herbicides. Outdoors, VOCs are released into the air mainly during manufacture or use of such products. Indoors, in addition to interior painting, VOCs are released into the air mainly from the use of household and janitorial products. VOCs are of concern as both indoor and outdoor air pollutants; however, the concerns are different. Indoors, the main concern is human health impacts. Outdoors, air districts and the USEPA regulate VOCs mainly because they contribute – along with NO_X – to the formation of photochemical ozone.

> The USEPA, per 40 Code of Federal Regulations (CFR) 51.100(s), defines VOCs as any compound of carbon, excluding carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, and ammonium carbonate, which participates in atmospheric photochemical reactions, except those designated by the USEPA as having negligible photochemical reactivity (USEPA 2009c).

> Scientific literature generally defines VOCs as organic chemical compounds whose composition makes it possible for them to evaporate under normal atmospheric conditions of temperature and pressure. The volatility of an organic compound is inversely proportional to its boiling point (BP), i.e., the lower the BP, the higher its volatility (USEPA 2014).

The European Union (2004) defines a VOC as any organic compound having an initial BP less than or equal to 482°F (250°C) measured at standard atmospheric pressure at sea level (760 millimeters mercury or 14.7 pounds per square inch absolute). The World Health Organization (1989) categorizes organic pollutants as very volatile, volatile, and semivolatile. Very volatile organic compounds (VVOCs) are so volatile that they typically exist as gases rather than being present in materials. Semivolatile organic compounds (SVOCs) and particulate organic matter (POM) constitute very small fractions of the total amount of organic pollutants found in air, mainly because they are liquids or solids at ambient temperature. Between VVOCs and SVOCs are VOCs, which include several common species of organic pollutants. The four broad categories of organic air pollutants are described below (WHO 1989; Underwriter Laboratories 2012):

> Very volatile organic compounds (VVOCs) have BPs less than 122°F (50°C), most are gases at ambient temperature, and include compounds such as propane, butane, pentane, formaldehyde, acetaldehyde, and methyl chloride (chloromethane). Of these, formaldehyde and acetaldehyde are present in gasoline and diesel engine exhaust.

> Volatile organic compounds (VOCs) have BPs in the range to 122 to 482°F (50 to 250°C) and include compounds such as hexane, benzene, toluene, ethylbenzene, xylenes (collectively referred to as BTEX), acetone, methyl alcohol (methanol), ethyl alcohol (ethanol), and isopropyl alcohol (2-propanol or isopropanol). Compounds such as BTEX are present in gasoline and diesel engine exhaust.

> Semivolatile organic compounds (SVOCs) have BPs in the range of 482 to 716°F (250 to 380°C) and include compounds such as polycyclic aromatic hydrocarbons (PAHs), pesticides (e.g., chlordane), plasticizers (e.g., phthalates), and fire retardants (e.g., polychlorinated biphenyls, polybrominated biphenyls). Diesel Particulate Matter (DPM) in diesel engine exhaust contains compounds such as PAHs.

> Particulate organic matter (POM) has BPs greater than 716°F (380°C) and includes the heavier compounds of DPM, which are essentially nonvolatile in the ambient environment.

In addition, petroleum middle distillates have BPs in the range of 300 to 700°F (150 to 370°C) – between VOCs and SVOCs – and include common fuels such as kerosene (BP 150 to 275°C), diesel fuel (BP 150 to 370°C), and aviation jet fuels (initial BP 175°C). In certain applications, which are not common, kerosene may be used as a carrier solvent for some types of pesticides and herbicides. However, due to its relatively low volatility, kerosene does not evaporate readily at ambient temperatures.

In California and the United States, VOC emissions to the outdoors are regulated by air districts (e.g., BAAQMD) and the USEPA mainly to reduce the formation of ozone, a constituent of photochemical smog. However, not all VOCs are considered photochemically reactive. VOCs that are nonreactive or of negligible reactivity are exempted from the definition of VOCs used by air districts and the USEPA (2009c). Since California has 35 air districts – including the BAAQMD – the specific definition of VOCs can change somewhat depending on jurisdiction. (USEPA 2014)

The USEPA formerly defined the regulated organic compounds in outdoor air as reactive organic gases (ROGs), while some air districts adopted the term reactive organic compounds (ROCs). These terminologies clarified the meanings as being limited to photochemically reactive compounds. However, the USEPA later changed its terminology to VOCs to include substances that may not be reactive but could be harmful to human health in high enough concentrations, particularly indoors. Reducing VOCs indoors and outdoors is an important health and environmental goal. However, VOCs that may be of health risk concern do not impact photochemical reactions and, therefore, are not regulated by the USEPA or air districts (42 USC 7401 et seq. 1970).

As described above, the primary sources of VVOC and VOC emissions from mosquito abatement and vector control activities are from gasoline and diesel engines used to power application equipment and transport personnel and materials. Also included are aircraft emissions, mainly from turbine-powered helicopters burning jet fuel. Further, SVOC and POM emissions from diesel engines in the form of DPM are of particular concern because PAHs are carcinogenic (BAAQMD 2004; OEHHA 2009). Other SVOCs contained in mosquito abatement and vector control materials would be emitted in relatively minor quantities during application activities compared to engine exhaust and would be neither substantial nor cumulatively considerable (see Section 10.2.2).

10.1.6 Regulatory Framework

The following paragraphs summarize the federal, state, and local agencies and the laws and regulations governing air quality that are provided in Appendix C. It is the practice of the District to work with Service Area jurisdictions and agencies during Program planning to reasonably consider the local environmental protection policies and to conform to the extent required.

10.1.6.1 Standards and Attainment Status

The Clean Air Act of 1970 (CAA, amended 1977 and 1990, 42 USC §7401 et seq.) established NAAQS, and individual states retained the option to adopt more stringent standards and to include other pollution sources. CAAQS tend to be at least as protective as national standards and are often more stringent.

The ambient air quality standards shown in Table 10-1 are intended to protect the public health and welfare and specify the concentration of pollutants (with an adequate margin of safety) to which the public may be exposed without adverse health effects. The standards are designed to protect those segments of the public most susceptible to respiratory distress (known as sensitive receptors), including asthmatics, the very young, the elderly, people weak from other illness or disease, or persons engaged in strenuous work or exercise. Healthy adults can tolerate occasional exposure to air pollution levels somewhat above the ambient air quality standards before adverse health effects are observed.

In general, the San Francisco Bay Area experiences low concentrations of most pollutants when compared to state and federal standards, except for O_3 and particulate matter, for which standards are periodically exceeded. Portions of Sonoma County and Yolo-Solano counties also experience mildly

elevated concentrations of O_3, resulting in state and federal nonattainment designations. The attainment status of the main Bay Area region is shown in Table 10-2.

Table 10-1 Ambient Air Quality Standards

Pollutant	Averaging Time	California Standards		Federal Standards	
		ppmv	µg/m³	ppmv	µg/m³
Ozone (O_3)	1-hour	0.09	177	—	—
	8-hour	0.07	137	0.075	147
Nitrogen Dioxide (NO_2)	1-hour	0.18	338	0.100	188
	Annual	0.03	56	0.053	100
Sulfur Dioxide (SO_2)	1-hour	0.25	655	0.075	196
	3-hour Secondary	—	—	0.50	1,309
	24-hour	0.04	105	—	—
	Annual	—	—	0.03	79
Carbon Monoxide (CO)	1-hour	20	22,898	35	40,071
	8-hour	9	10,304	9	10,304
	Lake Tahoe (8-hr)	6	6,869	—	—
Particulates (as PM_{10})	24-hour	—	50	—	150
	Annual	—	20	—	—
Particulates (as $PM_{2.5}$)	24-hour	—	—	—	35
	Annual Primary	—	12	—	12
	Annual Secondary	—	—	—	15
Lead (Pb)	30-day	—	1.5	—	—
	3-month (rolling)	—	—	—	0.15
Sulfates (as SO_4)	24-hour	—	25	—	—
Hydrogen Sulfide (H_2S)	1-hour	0.03	42	—	—
Vinyl Chloride (C_2H_3Cl)	24-hour	0.01	26	—	—
Visibility Reducing Particles	8-hour	Extinction coefficient of 0.23 per kilometer; visibility of 10 miles or more (0.07 to 30 miles or more for Lake Tahoe) due to particles when relative humidity is less than 70 percent.		—	—

Sources: BAAQMD 2014; CARB 2013b

ppmv = part(s) per million by volume

µg/m³ = microgram(s) per cubic meter

The 1.5 µg/m³ federal quarterly lead standard applied until 2008; 0.15 µg/m³ rolling 3-month average thereafter For gases, µg /m³ calculated from ppmv based on molecular weight and standard conditions. Standard Temperature 25°C. Standard Molar Volume 24.465 liter/g-mole

Table 10-2 Attainment Status Summary - Bay Area Region

Criteria Pollutant	State Designation	Federal Designation
Ozone (O_3) (1-hour)	Nonattainment	—
Ozone (O_3) (8-hour)	Nonattainment	Nonattainment(1)
Nitrogen Dioxide (NO_2) (1-hour)	Attainment	Unclassified(2)
Nitrogen Dioxide (NO_2) (annual)	Attainment	Attainment
Sulfur Dioxide (SO_2)	Attainment	Attainment
Carbon Monoxide (CO)	Attainment	Attainment
Resp. Particulates (as PM_{10}) (24-hour)	Nonattainment	Unclassified(2)
Resp. Particulates (as PM_{10}) (annual)	Nonattainment	—
Fine Particulates (as $PM_{2.5}$) (24-hour)	—	Nonattainment
Fine Particulates (as $PM_{2.5}$) (annual)	Nonattainment	Attainment
Lead (Pb)	Attainment	Attainment
Sulfates (as SO_4)	Attainment	—
Hydrogen Sulfide (H_2S)	Unclassified(2)	—
Vinyl Chloride (C_2H_3Cl)	ND	—
Visibility	Unclassified(2)	—

Sources: BAAQMD 2014; CARB 2013a

ND = no data/information available

Notes:

(1) The 0.08 ppmv federal 8-hour O_3 standard applied until 2008; 0.075 ppmv thereafter

(2) At the time of designation, if the available data do not support a designation of attainment or nonattainment, the area is designated as unclassified.

10.1.6.2 Federal Authority

The 1977 CAA amendments required that regional planning and air pollution control agencies prepare regional air quality plans to outline the measures by which both stationary and mobile sources of pollutants can be controlled to achieve all standards by the deadlines specified in the act.

For the SFBAAB, the Association of Bay Area Governments, the Metropolitan Transportation Commission, and BAAQMD jointly prepared the *2005 Bay Area Ozone Strategy* (2005), which provided inputs to the most recent *2010 Clean Air Plan* (2010b) issued by BAAQMD. These plans contain control strategies that demonstrate attainment with NAAQS by the deadlines established in the federal CAA and become part of the State Implementation Plan (SIP) administered by CARB and submitted to USEPA. Similarly, NSCAPCD, YSAQMD, and MCAQMD are also required to prepare and submit tailored clean air implementation plans to state and federal regulators.

Under the 1990 CAA amendments, areas that did not meet the original federal 1-hour O_3 standard were classified according to the severity of each area's respective O_3 problem. The 1-hour classifications were Marginal, Moderate, Serious, Severe, and Extreme.

10.1.6.3 State Authority

In 1988, the California legislature passed the California CAA (California Health and Safety Code Section 39600 et seq.), which, like its federal counterpart, called for designations of areas as attainment or nonattainment based on state rather than federal standards.

Similar to the federal CAA, the California CAA also classifies areas according to pollution levels. Under the California CAA, the Bay Area is a "Serious" O_3 nonattainment area and state PM_{10} and $PM_{2.5}$ nonattainment areas. In addition, localized CO concentrations, also known as CO "hotspots," may occur at heavily traveled roadways, particularly at intersections or other locations where the traffic is congested and vehicles idle for prolonged periods. CO concentrations exceeding the existing standard may occur at intersections that operate at a Level of Service D or worse.

CARB is the state agency responsible for regulating air quality, and its responsibilities include establishing CAAQS, emissions standards, and regulations for mobile emissions sources (e.g., autos, trucks, etc.) as well as overseeing the efforts of countywide and multicounty air pollution control districts, which have primary responsibility over stationary sources. The emission standards most relevant to the Program are those related to automobiles, light- and medium-duty trucks, and California heavy-duty truck and construction equipment engines.

10.1.6.4 Local Authority

BAAQMD is the regional agency responsible for air quality regulation within the San Francisco Bay Area along with NSCAPCD, YSAQMD, MCAQMD, and LCAQMD in their respective jurisdictions. Air quality is regulated through planning, monitoring, rulemaking, permitting, and enforcement activities. Districts have permit authority over most types of stationary emission sources and can require stationary sources to obtain permits; they can also impose emission limits, set fuel or material specifications, or establish operational limits to reduce air emissions. BAAQMD also regulates new or expanding stationary sources of toxic air contaminants. For state air quality planning purposes, the Bay Area is classified by the California CAA as a nonattainment area for O_3. The "Serious" classification triggers various plan submittal requirements and transportation performance standards. One such requirement is that each district update its air quality attainment plan every 3 years (triennially) to reflect progress in meeting the air quality standards and to incorporate new information regarding the feasibility of control measures and new emission inventory data. Districts indirectly regulate construction projects that use mobile sources via the statewide Portable Equipment Registration Program (PERP) discussed below. Since the Program does not meet the definition of permanent stationary sources, no permits would be required from the BAAQMD, NSCAPCD, YSAQMD, MCAQMD, or LCAQMD.

10.1.6.5 Source-Specific Regulations

10.1.6.5.1 Nonroad Engine Standards

CARB regulates mobile sources of air pollution in the State of California. Self-propelled nonroad construction equipment is considered a vehicle, as defined by the California Vehicle Code. A vehicle may have an engine that both propels the vehicle and powers equipment mounted on the vehicle. As such, vehicles are generally exempt from regulation by the air districts. However, not included in exemption provisions is any equipment mounted on a vehicle that would otherwise require a permit under air district rules and regulations.

Federal Tier 1 standards for offroad diesel engines were adopted as part of the California requirements for 1995. Federal Tier 2 and Tier 3 standards were adopted in 2000 and selectively apply to the full range of diesel offroad engine power categories. Both Tier 2 and Tier 3 standards include durability requirements to ensure compliance with the standards throughout the useful life of the engine (40 CFR 89.112, 13 California Code of Regulations [CCR] 2423).

On May 11, 2004, the USEPA signed the final rule implementing Tier 4 emission standards, which are to be phased-in over the period of 2008 to 2015 (69 Federal Register 38957-39273, 29 June 2004). The Tier 4 standards require that PM and NO_X emissions be further reduced by about 90 percent. Such emission reductions can be achieved through the use of advanced control technologies – including advanced exhaust gas after treatment similar to those required by the 2007–2010 standards for highway diesel engines.

10.1.6.5.2 Portable Equipment Registration Program

The statewide PERP establishes a uniform program to regulate portable engines and portable engine-driven equipment units. Once registered in PERP, engines and equipment units may operate throughout California without the need to obtain individual permits from local air districts such as BAAQMD, NSCAPCD, YSAQMD, MCAQMD, and LCAQMD. Owners or operators of portable engines and certain types of equipment can register their units under the PERP to operate their equipment anywhere in the state. (CARB 2012a)

BAAQMD operates stipulated enforcement programs for owners and operators of portable equipment, which does not comply with CARB's Portable Diesel Airborne Toxic Control Measure (ATCM) regulation. Under this rule, any portable diesel engine not registered in the PERP prior to January 1, 2006, is illegal, and may not be operated in California unless it meets the ATCM Tier requirements or has an operating permit issued by an air district.

BAAQMD Regulation 2, Sections 2-1-105 and 2-1-114 list types of portable equipment commonly used in construction as exempt from stationary source rule requirements provided that the equipment complies with all applicable requirements of the statewide PERP pursuant to 13 CCR, Division 3, Chapter 3, Article 5. The District's Proposed Program is not subject to BAAQMD permitting requirements because the Program would not involve any stationary air pollution sources that are subject to BAAQMD review, including engine-driven pumps, generators, and air compressors.

10.1.6.5.3 Air Toxics Control Measures

On July 26, 2007, CARB adopted a regulation to reduce DPM and NO_X emissions from in use (existing) offroad heavy-duty diesel vehicles in California. Such vehicles are used in construction, mining, and industrial operations. Not included in this category are locomotives, commercial marine vessels, marine engines over 50 horsepower, or recreational vehicles. The ATCM regulation supplements existing tiered emission standards for nonroad diesel engines in California (CARB 2012b).

10.1.6.5.4 Senate Bill 656

Senate Bill 656 is a planning requirement that calls for a plan and strategy for reducing $PM_{2.5}$ and PM_{10}. This bill requires CARB to identify, develop, and adopt a list of control measures to reduce the $PM_{2.5}$ and PM_{10} emissions from new and existing stationary, mobile, and area sources. BAAQMD has developed particulate matter control measures and submitted plans to CARB that include lists of measures to reduce particulate matter. Under the plans, air districts are required to continue to assess $PM_{2.5}$ and PM_{10} emissions and their impacts.

For construction emissions of fugitive PM_{10}, California air districts have adopted a number of feasible control measures that can be reasonably implemented to significantly reduce fugitive PM_{10} emissions from construction. In general, most districts' approach to CEQA analyses of construction impacts is to emphasize implementation of effective and comprehensive control measures rather than detailed quantification of emissions.

10.1.6.5.5 Nuisance (Odors)

BAAQMD CEQA Air Quality Guidelines (BAAQMD 2011) require an assessment of a project's potential to cause a public nuisance by subjecting surrounding land uses (receptors) to objectionable odors. Due to proximity, NSCAPCD and YSAQMD generally follow the BAAQMD guidelines (NSCAPCD 2012; YSAQMD 2013).

Nuisance is a fundamental air pollution control rule across the state in all air districts, including NSCAPCD Rule 400 and YSAQMD Rule 2.5, and typically contain the same language as BAAQMD Regulation 1, Rule 301 which states that "No person shall discharge from any source whatsoever such quantities of air contaminants or other material which cause injury, detriment, nuisance or annoyance to any considerable number of persons or the public; or which endangers the comfort, repose, health or safety of any such persons or the public, or which causes, or has a natural tendency to cause, injury or damage to business or property."

BAAQMD Regulation 7, Rule 102 defines an objectionable odor problem as when the Air Pollution Control Officer "receives odor complaints from ten or more complainants within a 90-day period, alleging that a person has caused odors perceived at or beyond the property line of such person and deemed to be objectionable by the complainants in the normal course of their work, travel, or residence." The assessment protocol includes projects that have the potential to cause odors or projects that may subject potential sensitive receptors to nearby existing or proposed land uses that emit objectionable odors.

Some of the pesticides used for mosquito control have an unpleasant odor in concentrated form, in particular the Bti liquids and the adulticides pyrethrin and permethrin. Bti liquids, when diluted with water and sprayed onto water containing breeding mosquitoes, have almost no odor within a few minutes of application. The adulticides pyrethrin and permethrin have no residual smell once the ULV fog dissipates (about 20 minutes maximum). The BVA-2 oil has an odor, although once applied (3 to 5 gallons per acre) not much odor remains.

10.1.6.5.6 Toxic Air Contaminants

A project with the potential to expose sensitive receptors (including residential areas) or the general public to substantial levels of toxic air contaminants, as designated by CARB under 17 CCR 93001, listed in BAAQMD's Toxic Air Contaminants Inventory (BAAQMD 2004), would be deemed to have a significant impact. Projects that would locate receptors near existing sources of toxic air contaminants are included, as well as projects that would place sources of toxic air contaminants near existing receptors.

Projects that have the potential to expose the public to toxic air contaminants in excess of the following thresholds would be considered to have a significant air quality impact for receptors within 1,000 feet of a source boundary. These thresholds, which are based on the 2010/2011 BAAQMD CEQA Air Quality Guidelines (BAAQMD 2011), are as follows:

> Probability of contracting cancer for the Maximally Exposed Individual (MEI) that exceeds 10 in 1 million. The MEI is a hypothetical person exposed for 70 years continuously (24 hours per day, 365 days per year).

> Ground-level concentrations of chronic or acute noncarcinogenic toxic air contaminants that result in a Hazard Index greater than 1 for the MEI.

> Ambient $PM_{2.5}$ increase greater the 0.3 $\mu g/m^3$ on an annual average basis.

DPM is considered a toxic air contaminant in California (Section 93000). Due to the limited use of diesel-powered vehicles and equipment and the Program's wide geographic scope, DPM emissions would not be sufficient to pose a significant risk to sensitive receptors from mosquito and/or vector control equipment operations.

10.1.6.5.7 General Conformity

A General Conformity determination is required for federally sponsored, permitted, or funded actions in NAAQS nonattainment areas or in certain maintenance areas when the total direct and indirect net emissions of nonattainment pollutants (or their precursors) exceed specified thresholds (CAA Amendments of 1990 Section 176[c]). This regulation ensures that federal actions conform to SIPs and agency NAAQS attainment plans.

As discussed in Section 10.1.6 and shown in Table 10-2, the Bay Area region is in federal nonattainment for $PM_{2.5}$ and O_3. Thus, the emissions of nonattainment pollutants NO_X, VOCs, PM_{10}, and $PM_{2.5}$ would be subject to the Rule if the Program were a federal action. However, since the Program is a local action and not federally sponsored, permitted, or funded action, General Conformity does not apply.

10.2 Environmental Impacts and Mitigation Measures

10.2.1 Evaluation Concerns and Criteria

The environmental concerns are those identified below from the CEQA Guidelines and from public scoping. The public identified the following issues:

> Address impacts of spraying/fogging on air quality for humans and pets alike.

> Address impacts of emissions of air pollutants from control and treatment methods and combustion of fuels.

The focus in this chapter is on the use of equipment to perform all Program activities and the resulting emissions impacts to air quality. Concerning the chemical treatment methods, the effects of applications of those specific chemicals is addressed in Section 6.2 for ecological health and Section 7.2 for human health. The CEQA Guidelines cover the issues from public scoping.

10.2.1.1 Standards of Significance

The PEIR addresses the following criteria/standards of significance for air resources as based on CEQA Guidelines Appendix G, *Environmental Checklist Form*, Section III. Would the project:

> Conflict with or obstruct implementation of the applicable Air Quality Attainment Plan or Congestion Management Plan?

> Violate any stationary source air quality standard or contribute to an existing or projected air quality violation?

> Result in a net increase of any criteria pollutant for which the project region is nonattainment under an applicable federal or state ambient air quality standard (including releasing emissions, which exceed quantitative thresholds for ozone precursors)?

> Expose sensitive receptors to substantial pollutant concentrations?

> Create objectionable odors affecting a substantial number of people?

For this Program, determinations made with respect to significance criteria are documented in Sections 10.2.3 through 10.2.8.

10.2.1.1.1 BAAQMD CEQA Guidelines

On June 2, 2010, the BAAQMD Board adopted a significant update to its December 1999 *CEQA Air Quality Guidelines*. BAAQMD subsequently issued clarifications and minor edits to the June 2010 Guidelines. The revised *CEQA Air Quality Guidelines* is a guidance document to provide lead government agencies, consultants, and project proponents with uniform procedures for assessing air quality impacts and preparing the air quality sections of environmental documents for projects subject to CEQA. The document describes the criteria that BAAQMD uses when reviewing and commenting on the adequacy of environmental documents. It recommends quantitative thresholds for use in determining whether construction and operational activities associated with projects would have significant adverse environmental impacts, identifies methodologies for predicting project emissions and impacts, and identifies measures that can be used to avoid or reduce air quality impacts. (BAAQMD 2011, 2012a)

However, due to a legal challenge,[2] the adopted 2011 Guidelines and significance thresholds (BAAQMD 2011) are no longer officially in effect. Per the revised and adopted 2012 Guidelines (BAAQMD 2012a), lead agencies have the discretion to use either the adopted 1999 thresholds or the more stringent 2010/2011 thresholds.[3] At MSMVCD's request, the air quality analysis will follow the 2010/2011 significance thresholds because MSMVCD has determined that Appendix D of the Guidelines, in combination with BAAQMD's Revised Draft Options and Justification Report (BAAQMD 2009), provides substantial evidence to support the 2010/2011 significance thresholds and, therefore, has determined they are appropriate for use in this analysis in lieu of the 1999 significance thresholds.

For the PEIR, air quality impacts will be quantitatively assessed using significance thresholds established by BAAQMD in its 2010/2011 CEQA Guidelines for nonattainment pollutants and USEPA for attainment pollutants, which are listed in Table 10-3. Federal Prevention of Significant Deterioration thresholds contained in 40 CFR 51.166(b)(23)(i) applicable to NSCAPCD are also higher than BAAQMD thresholds. The 2010/2011 BAAQMD thresholds are the most stringent (lowest) quantitative criteria for assessing the potential for all Program impacts under CEQA.

[2] On March 5, 2012, Alameda County Superior Court issued a judgment finding that BAAQMD had failed to comply with CEQA when it adopted the Thresholds. The court did not determine whether the Thresholds were valid on the merits, but found that the adoption of the Thresholds was a project under CEQA. The court issued a writ of mandate ordering BAAQMD to set aside the Thresholds and cease dissemination of them until BAAQMD had complied with CEQA. BAAQMD has appealed the Alameda County Superior Court's decision. The Court of Appeal of the State of California, First Appellate District, reversed the trial court's decision. The Court of Appeal's decision was appealed to the California Supreme Court, which granted limited review, and the matter is currently pending there.

[3] Due to the March 5, 2012, writ of mandate, which sets aside BAAQMD's adopted 2010 CEQA Thresholds of Significance, BAAQMD cannot recommend specific thresholds of significance for use by local governments at this time (October 2014). Lead agencies will need to determine appropriate air quality thresholds to use for each project they review based on substantial evidence that they should include in the administrative record for the project. Lead agencies should examine the substantial evidence in determining appropriate air quality thresholds. Lead agencies may reference BAAQMD's 1999 Thresholds of Significance. Lead agencies may also reference BAAQMD's CEQA Thresholds Options and Justification Report developed by staff in 2009. The CEQA Thresholds Options and Justification Report outlines substantial evidence supporting a variety of thresholds of significance. In accordance with the court order referenced above, the Air District cannot and does not endorse or recommend any of the particular thresholds outlined therein.

Table 10-3 CEQA Significance Thresholds - BAAQMD (2010/2011)[1]

Criteria Pollutants, Precursors, GHGs, Risks and Odors	Construction lbs/day	Operation	
		lbs/day	tons/yr
Reactive Organic Gases (ROGs)	54	54	10
Nitrogen Oxides (NO_X)	54	54	10
Sulfur Dioxide (SO_2)[2]	None	None	40
PM_{10} (exhaust)	82	82	15
$PM_{2.5}$ (exhaust)	54	54	10
PM_{10} / $PM_{2.5}$ (fugitive dust)[3]	BMPs	None	
Local Carbon Monoxide (CO)[4]	None	CAAQS: 9 ppmv (8-hr); 20 ppmv (1-hr)	
GHGs - Stationary Sources	None	10,000 MT CO_2e/year	
GHGs - Other than Stationary Sources	None	Compliance with GHG Reduction Strategy OR 1,100 MT of CO_2e/yr OR 4.6 MT CO_2e/SP/yr (res + emp)	
Risks & Hazards (individual project)	Compliance with Community Risk Reduction Plan OR Increased cancer risk of >10.0 in a million; Increased noncancer risk of >1.0 Hazard Index (Chronic or Acute); Ambient $PM_{2.5}$ increase: >0.3 µg/m^3 annual average		
Risks & Hazards (cumulative threshold)	Compliance with Community Risk Reduction Plan OR Increased cancer risk of >100.0 in a million; Increased noncancer risk of >10.0 Hazard Index (Chronic or Acute); Ambient $PM_{2.5}$ increase: >0.8 µg/m^3 annual average		
Accidental Release of Acutely Hazardous Air Pollutants/Materials	None	Storage or use of acutely hazardous materials located near receptors or new receptors locating near stored or used acutely hazardous materials are considered significant	
Odors	None	5 confirmed complaints per year averaged over 3 years	

Source: BAAQMD 2011 (see note 1), 40 CFR 51.166 (see note 2)

Notes:

[1] At the request of MSMVCD, the air quality analysis will follow the 2010/2011 draft significance thresholds. This is because MSMVCD has determined that Appendix D of the guidelines, in combination with BAAQMD's Revised Draft Options and Justification Report (BAAQMD 2009), provides substantial evidence to support the 2010 significance thresholds and, therefore, has determined they are appropriate for use in this analysis in lieu of the 1999 significance thresholds.

[2] Prevention of Significant Deterioration, annual only

[3] BMPs = Best Management Practices for control of fugitive dust

[4] Not to exceed California Ambient Air Quality Standards for CO

10.2.2 Evaluation Methods and Assumptions

As described in Section 10.1.5, operation of onroad fleet vehicles, offroad all-terrain vehicles, watercraft, aircraft, portable equipment, and small equipment would result in emissions of criteria pollutants (NO_X, VOCs, CO, SO_X, PM_{10}, $PM_{2.5}$) in engine exhaust. Detailed lists of equipment, estimated usage, and emission calculations are provided in Appendix C, in Attachment A. Equipment lists and annual activity schedules were provided by the District. Emission calculations were performed using the most recent and applicable emission factors published by CARB (2008a), Hare and Springer 1973, and USEPA (1991d, 2011a, 2011b, 2012a).

From Table 2-6 in Section 2.9, the District is implementing BMPs to avoid or minimize environmental impacts from applications of pesticides, surfactants, and/or herbicides (category H) under the Vegetation Management and/or Chemical Control Alternatives. The impact significance determinations assume that the District will continue to implement the following BMPs:

1. District staff will conduct applications with strict adherence to product label directions that include approved application rates and methods, storage, transportation, mixing, and container disposal. (BMP H1)
2. District will avoid use of surfactants when possible in sites with aquatic nontargets or natural enemies of mosquitoes present such as nymphal damselflies and dragonflies, dytiscids, hydrophilids, corixids, notonectids, ephydrids, etc. Surfactants are the only tool that can be used with pupae to prevent adult mosquito emergence. The District will use a microbial larvicide (Bti, Bs) or IGR (e.g., methoprene) instead or another alternative when possible. (BMP H2)
3. Materials will be applied at the lowest effective concentration for a specific set of vectors and environmental conditions. Application rates will never exceed the maximum label application rate. (BMP H3)
4. To minimize application of pesticides, application of pesticides will be informed by surveillance and monitoring of vector populations. (BMP H4)
5. District staff will follow label requirements for storage, loading, and mixing of pesticides and herbicides. Handle all mixing and transferring of herbicides within a contained area. (BMP H5)
6. Postpone or cease application when predetermined weather parameters exceed product label specifications, when wind speeds exceed the velocity as stated on the product label, or when a high chance of rain is predicted and rain is determining factor on the label of the material to be applied. (BMP H6)
7. Applicators will remain aware of wind conditions prior to and during application events to minimize any possible unwanted drift to waterbodies, and other areas adjacent to the application areas. (BMP H7)
8. Spray nozzles will be adjusted to produce larger droplet size rather than smaller droplet size. Use low nozzle pressures where possible (e.g., 30 to 70 pounds per square inch). Keep spray nozzles within a predetermined maximum distance of target weeds (e.g., within 24 inches of vegetation for hand application) or vectors. Adjusting droplet size would only apply to larvicides, herbicides, and non-ULV applications. Use ULV applications that are calibrated to be effective and environmentally compatible at the proper droplet size (about 10 to 30 microns). (BMP H8)
9. Clean containers at an approved site and dispose of at a legal dumpsite or recycle in accordance with manufacturer's instructions if available. (BMP H9)
10. The District will provide notification to the public (24 to 48 hours in advance, if possible) and/or appropriate agency(ies) when applying pesticides or herbicides for large-scale treatments (e.g., fixed-wing aircraft or helicopters) that will occur in close proximity to homes, heavily populated, high traffic,

and sensitive areas. The District infrequently applies or participates in the application of herbicides in areas other than District facilities. (BMP H13)

11. Engine idling times will be minimized either by shutting equipment and vehicles off when not in use or reducing the maximum idling time to 5 minutes. Correct tire inflation will be maintained in accordance with manufacturer's specifications on wheeled equipment and vehicles to prevent excessive rolling resistance. All equipment and vehicles will be maintained and properly tuned in accordance with manufacturer's specifications. All equipment will be checked by a certified visible emissions evaluator if visible emissions are apparent to onsite staff. (BMP A14)

Chapter 8, *Public Services and Hazard Response*, provides additional information on the District's spill prevention and worker safety plans.

10.2.2.1 Emissions from Equipment Use

Table 10-4 shows alternatives' equipment use applicability by percentage as selected by the District: surveillance, physical control, vegetation management, biological control, chemical control, or other nonchemical control. Table 10-5 shows land uses associated with selected alternatives: residential, commercial, industrial, agricultural, and open space.

Table 10-4 Marin/Sonoma Mosquito and Vector Control District's Selected Alternatives Applicability

Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical
20%	5%	13%	21%	25%	15%

Sources: Appendix C, Marin-Sonoma Mosquito and Vector Control District

Table 10-5 Land Uses Associated with Selected Alternatives for Marin/Sonoma Mosquito and Vector Control District

Residential	Commercial	Industrial	Agricultural	Open Space
•	•	•	•	•

Sources: Appendix C, Marin-Sonoma Mosquito and Vector Control District

Tables 10-6 through 10-11 show estimated ongoing annual criteria emissions by alternative for the District from vehicle and equipment use. Table 10-12 shows estimated peak daily criteria emissions for applicable alternatives assuming simultaneous operations of all alternatives as a hypothetical and highly unlikely "worst-case" scenario. Table 10-13 shows estimated highest quarterly and average daily criteria emissions for applicable alternatives assuming concurrent operations as "typical case," which is a more likely and realistic scenario.

Table 10-6 Estimated Annual Criteria Emissions for Surveillance Alternative for Marin/Sonoma Mosquito and Vector Control District

VOCs lbs/year	CO lbs/year	NO_X lbs/year	SO_X lbs/year	PM_{10} lbs/year	$PM_{2.5}$ lbs/year
132	2,515	298	3.5	19.5	13.9

Sources: CARB 2008a; Hare and Springer 1973; USEPA 1991b, 2011a, 2011b, 2012a

Table 10-7 Estimated Annual Criteria Emissions for Physical Control Alternative for Marin/Sonoma Mosquito and Vector Control District

VOCs lbs/year	CO lbs/year	NO_X lbs/year	SO_X lbs/year	PM_{10} lbs/year	$PM_{2.5}$ lbs/year
36	689	82	1.0	5.3	3.8

Sources: CARB 2008a; Hare and Springer 1973; USEPA 1991b, 2011a, 2011b, 2012a

Table 10-8 Estimated Annual Criteria Emissions for Vegetation Management Alternative for Marin/Sonoma Mosquito and Vector Control District

VOCs lbs/year	CO lbs/year	NO_X lbs/year	SO_X lbs/year	PM_{10} lbs/year	$PM_{2.5}$ lbs/year
89	1,700	201	2.4	13.2	9.4

Sources: CARB 2008a; Hare and Springer 1973; USEPA 1991b, 2011a, 2011b, 2012a

Table 10-9 Estimated Annual Criteria Emissions for Biological Control Alternative for Marin/Sonoma Mosquito and Vector Control District

VOCs lbs/year	CO lbs/year	NO_X lbs/year	SO_X lbs/year	PM_{10} lbs/year	$PM_{2.5}$ lbs/year
141	2,683	318	3.7	20.8	14.8

Sources: CARB 2008a; Hare and Springer 1973; USEPA 1991b, 2011a, 2011b, 2012a

Table 10-10 Estimated Annual Criteria Emissions for Chemical Control Alternative for Marin/Sonoma Mosquito and Vector Control District

VOCs lbs/year	CO lbs/year	NO_X lbs/year	SO_X lbs/year	PM_{10} lbs/year	$PM_{2.5}$ lbs/year
167	3,168	375	4.4	24.5	17.5

Sources: CARB 2008a; Hare and Springer 1973; USEPA 1991b, 2011a, 2011b, 2012a

Table 10-11 Estimated Annual Criteria Emissions for Other Nonchemical Control/Trapping Alternative for Marin/Sonoma Mosquito and Vector Control District

VOCs lbs/year	CO lbs/year	NO_X lbs/year	SO_X lbs/year	PM_{10} lbs/year	$PM_{2.5}$ lbs/year
99	1,873	222	2.6	14.5	10.3

Sources: CARB 2008a; Hare and Springer 1973; USEPA 1991b, 2011a, 2011b, 2012a

Table 10-12 Estimated Peak Daily Criteria Emissions for Applicable Alternatives - Simultaneous Operations for Marin/Sonoma Mosquito and Vector Control District

VOCs lbs/day	CO lbs/day	NO_X lbs/day	SO_X lbs/day	PM_{10} lbs/day	$PM_{2.5}$ lbs/day
15.3	394.0	44.1	0.5	2.1	1.5

Sources: CARB 2008a; Hare and Springer 1973; USEPA 1991b, 2011a, 2011b, 2012a

Table 10-13 Estimated Highest Quarterly Criteria Emissions for Applicable Alternatives - Concurrent Operations for Marin/Sonoma Mosquito and Vector Control District

VOCs lbs/qtr	CO lbs/qtr	NO_X lbs/qtr	SO_X lbs/qtr	PM_{10} lbs/qtr	$PM_{2.5}$ lbs/qtr
223	4,369	485	6	33	23

Sources: CARB 2008a; Hare and Springer 1973; USEPA 1991b, 2011a, 2011b, 2012a

No annual or daily thresholds (Table 10-3) would be exceeded by the Program based on estimated mobile source (fuel combustion) emissions from existing activities. Due to the very wide spatial and temporal dispersion of the mobile emissions sources across the Service Area, no ambient air quality standards for any pollutant would be violated solely by mosquito and/or vector control activities. The District's combined annual or peak daily emissions would not be significant. Furthermore, emissions from continuation of existing activities under the Proposed Program in comparison to emissions from existing conditions when the NOP was published (May 25, 2012), would be practically zero (i.e., no substantial net change).

10.2.2.2 Emissions from Chemical Use

Examples of the estimated VOC emissions for some of the pesticide products the District uses are illustrated in Table 10-14 below. The table provides the estimated VOC emissions in pounds/acre for the products currently in use and some products proposed for future use. Using the known total acreage of application, the estimated total VOCs in pounds can be calculated for each product's active ingredient. Some of the active ingredients in the products listed have fairly high emission factors. However, even using these conservative use estimates, the VOC contributions are not significant to the ROG (VOC) operational thresholds contained in Table 10-3 of 54 pounds/day and 10 tons/year.

Since total pounds of product used per year is reported to CDPR, the total calculated VOC emissions for each product can be determined from the estimate of active ingredients. Using the CDPR VOC emission templates, the VOCs produced for three reporting years are listed in Table 10-14. Selected examples of four use scenarios are included in Tables 10-15 through 10-18. Each example calculation provided is the highest use year of 2006, 2008, and 2010 to illustrate the minimal impact of these VOCs in the overall potential contribution to total VOCs.

Some compounds are designated as exempt because they are not considered VOCs due to negligible photochemical reactivity. The exempt compounds are specified in 40 CFR 51.100. Products labeled only for nonagricultural uses are often excluded from the regulations. Nonagricultural uses include (a) home use, (b) use in structural pest control, (c) industrial or institutional use, (d) control of an animal pest under the written prescription of a veterinarian, or (e) vector control. All other uses are considered agricultural.

Table 10-14 Marin/Sonoma Mosquito and Vector Control District's Pesticide Use within Its Service Area

Pesticide (units)*	Active Ingredient	Amount of Active Ingredients		
		2006	2008	2010
Herbicides				
> Habitat (gal)	Imazapyr	0.00	0.55	0.00
	VOC lbs	**na**	**0.36**	**na**
> Liberate (gal)	Alcohol ethoxylate	0.00	0.55	0.00
	VOC lbs	**na**	**0.0**	**na**
Larvicides				
> BVA 2 (gal)	Mineral oil	0.00	0.00	681.73
	VOC lbs	**na**	**na**	**na**
> Golden Bear 1111 (gal)	Mineral oil	531.19	892.06	87.66
	VOC lbs	**na**	**na**	**na**
> Agnique MMF (gal)	Alcohol ethoxylate	41.28	29.81	52.33
	VOC lbs	**na**	**na**	**na**
> Agnique MMFG (lbs)	Alcohol ethoxylate	0.00	33.00	0.00
	VOC lbs	**na**	**na**	**na**
> VectoBac 12AS (gal)	Bti	106.6	69.41	83.5
	VOC lbs	**53.43**	**35**	**41.8**
> VectoBac Corncob Granules - BTI (lbs)	Bti	25.09	509.24	770.40
	VOC lbs	**0.93**	**18.8**	**28.5**
> VectoBac Technical Powder (lbs)	Bti	53.54	57.12	3.28
	VOC lbs	**0.0**	**0.0**	**0.0**
> VectoBac WDG (lbs)	Bti	0.00	0.00	14.00
	VOC lbs	**na**	**na**	**0.52**
> VectoLex WSP (lbs)	Bs	18.13	29.16	22.72
	VOC lbs	**0.67**	**1.08**	**0.84**
> VectoLex CG (lbs)	Bs	561	590	974
	VOC lbs	**20.8**	**21.8**	**36.0**
> VectoLex WDG (lbs)	Bs	91.8	153	166
	VOC lbs	**3.37**	**5.66**	**6.14**
> VectoMax CG (lbs)	Bs and Bti	0.00	0.00	974
	VOC lbs	**na**	**na**	**36**
> Altosid Liquid Larvicide (gal)	Methoprene	97.05	18.20	50.20
	VOC lbs	**5.65**	**11.64**	**31.5**
> Altosid Liquid Larvicide SR20 (gal)	Methoprene	0.00	0.00	0.35
	VOC lbs	**na**	**na**	**0.02**
> Altosid Briquets (small) (lbs)	Methoprene	0.3	0.15	0.12
	VOC lbs	**0.1**	**na**	**na**
> Altosid Pellets (lbs)	Methoprene	68	80.4	47
	VOC lbs	**1.3**	**2.27**	**1.33**

Pesticide (units)*	Active Ingredient	Amount of Active Ingredients		
		2006	2008	2010
> Altosid SBG (lbs)	Methoprene	9	6.3	2.7
	VOC lbs	**0.33**	**0.23**	**0.10**
> Altosid Briquets XR (lbs)	Methoprene	16.3	19	17
	VOC lbs	**0.6**	**0.70**	**0.63**
> Altosid XR granules (lbs)	Methoprene	15.92	0.01	0.00
	VOC lbs	**0.59**	**na**	**na**
Adulticides				
> Pyrocide 5% (gal)	Pyrethrin	1.1	0.41	0.81
	VOC lbs	**7.3**	**2.7**	**2.68**
> Scourge 4% + 12% MF (gal)	Resmethrin	0.00	1.83	0.00
	VOC lbs	na	4.12	na
> Zenivex (gal)	Etofenprox	0.00	0.00	0.90
	VOC lbs	**na**	**na**	**1.68**
Other Pesticides				
> Wasp Freeze (can)	Phenothrin	0.38	0.82	0.59
	VOC lbs	**0.0**	**0.0**	**0.0**
> Delta Dust (lbs)	Deltamethrin	1.62	0.06	23.90
	VOC lbs	**na**	**na**	**na**
> Drione Insecticides (lbs)	Pyrethrin	50.63	52.12	27.99
	VOC lbs	**0.77**	**0.80**	**0.43**
Other				
> Mosquito Fish (each)	na	10828	17485	19635
	VOC lbs	**na**	**na**	**na**
> Sand (lbs)	na	1188.81	1271.13	73.00
	VOC lbs	**na**	**na**	**na**
Total lbs	**VOC/yr**	**95.8**	**105.2**	**181.6**
	Tons/yr	**0.048**	**0.053**	**0.091**

Source: Marin/Sonoma Mosquito and Vector Control District, pesticide use reports.

*Unit of measure is for active ingredient used (calculated from total product used and reported) and number of mosquito fish.

na = not applicable

Table 10-15 Example VOC Calculation for VectoLex CG 2010

Product	VECTOLEX CG BIOLOGICAL LARVICIDE
CA Registration #	73049- 20-AA
VOC Emission Potential	3.70
Primary Active Ingredient	BACILLUS SPHAERICUS, SEROTYPE H-5A5B, STRAIN 2362
Formulation Type	GRANULAR/FLAKE
Application Rate	974 lbs
Total VOC Emissions	36.0 lbs

Table 10-16 Example VOC Calculation for Zoecon Altosid Pellets 2008

Product	ZOECON ALTOSID PELLETS
CA Registration #	2724- 448-ZA
VOC Emission Potential	2.82
Primary Active Ingredient	S-METHOPRENE
Formulation Type	GRANULAR/FLAKE
Application Total	80.4 lbs
Total VOC Emissions	2.27 lbs

Table 10-17 Example VOC Calculation for VectoBac 12AS for 2006

Product	VECTOBAC 12AS BIOLOGICAL LARVICIDE
CA Registration #	73049- 38-AA
VOC Emission Potential	5.71
Primary Active Ingredient	BACILLUS THURINGIENSIS, SUBSP. ISRAELENSIS, STRAIN AM 65-52
Formulation Type	SUSPENSION
Application Total	106.6 gallons
Total VOC Emissions	53.43 lbs

Table 10-18 Example VOC Calculation for Drione Powder 2008

Product	DRIONE INSECTICIDE
CA Registration #	432- 992-ZA
VOC Emission Potential	1.53
Primary Active Ingredient	SILICA AEROGEL, PYRETHRIN
Formulation Type	DUST/POWDER
Application Total	52.12 lbs
Total VOC Emissions	0.80 lb

For those compounds not considered exempt, the VOC contribution of most pesticides can be estimated by multiplying the fraction of a pesticide product estimated to be a VOC (its "emission potential") by the amount of that product applied. The results in Table 10-14 include the active ingredients reported by the District for illustration (even though the products are used for nonagricultural, vector control purposes).

For most compounds, determination of the estimated emission value is based on a laboratory analysis, using a standardized method called thermogravimetric analysis.

Each state keeps an inventory of emissions for each region or county. The lists of emission values for most compounds for the State of California measured in counties and regions for many compounds are located at www.cdpr.ca.gov.

Some of the VOCs of interest to the District are included in the list in CDPR's VOC emissions project website (CDPR 2014a, http://www.cdpr.ca.gov/docs/pur/vocproj/vocmenu.htm).

The VOC emission estimates are based on large uncertainties and, therefore, can be used only as an illustration of the possible VOC release. The VOC estimates for the pesticides the District uses are small compared to those illustrated for the vehicle and equipment use for concurrent operations (see Table 10-13). Each of the hundreds of individual pesticides, application rates, combinations of pesticides and surfactants, and application sequences can be used to estimate the VOCs using the calculator template the CDPR provided (CDPR 2014b).

An example of a VOC release calculation illustrates how small the VOC contribution from an application for vector control is compared to those of the equipment categories. Clearly, the contribution to O_3 production via the pesticide and herbicide applications is of interest, but not significant to the total impact of the District's IVMP to overall air quality.

In summary, although most pesticides used in nonagricultural applications do not rise to the level of a significant contribution to the overall VOC loading of the region, some VOC contribution as a result of pesticide applications can be estimated. In the examples above, the methodology used to estimate VOC contribution of selected pesticides (and herbicides) is based on the District's annual reported pesticide use in years 2006, 2008, and 2010. Some examples of the method used to estimate the VOC contribution calculated are illustrated in Tables 10-15 to 10-18. The rates of VOC contribution are nearly linearly dependent on the type of product, application rate (active ingredient/acre/application), and timing. Inspection of the highest total use in ounces/year resulted in the list of potential VOC emissions using the CDPR templates as described above. Clearly the estimates are dependent on timing and total area. These examples illustrate the very low potential production of VOC emissions due to pesticide product use. These total VOC production values are shown in Table 10-14. The reported annual use of the selected herbicides and pesticides and the calculated total VOC emissions from a typical application are listed for 2006, 2008, and 2010 and are based on pesticide use data the District reported to the County Agricultural Commissioners. More recent information on pesticide use by quarter is provided in Appendix B, *Ecological and Human Health Assessment Report*, Attachment A, Tables A21 through A26.

The total VOCs generated by the use of chemical control of undesirable vectors is small (from 95.8 lbs/yr in 2006 to 181.6 lbs/yr in 2010) in comparison to VOC contributions from all forms of equipment and vehicles (less than 664 lbs/year for all alternatives combined to 892 pounds/year based on highest quarterly emissions). Annual thresholds do not apply to estimated emissions shown herein because mosquito and vector control activities do not comprise a stationary source of air contaminants. Even so, VOC contribution from the District's vector control products is less than significant based on the CEQA significance thresholds. Consequently, the focus of the air quality impact analysis below is on transportation and equipment use for all of the Program alternatives.

10.2.3 Surveillance Alternative

The Surveillance Alternative would be a continuation of existing activities the District currently practices using applicable techniques, equipment, vehicles, and watercraft. Surveillance involves monitoring mosquito and/or vector populations and habitat, their disease pathogens, and the human/vector interactions. Field counting/sampling and trapping are common mechanisms for surveillance. The environmental impact concerns are phrased as questions as follows for the Surveillance Alternative.

Conflict with or obstruct implementation of the applicable Air Quality Attainment Plan or Congestion Management Plan?

The emission source categories associated with the Surveillance Alternative include offroad vehicles, onroad vehicles, and watercraft, all of which are mobile sources of nonattainment pollutants NO_X, VOCs, PM_{10}, and $PM_{2.5}$. As discussed in Section 10.1.6, these types of emission sources are included in the SIP emission inventory and required to meet CARB and USEPA nonroad and onroad emission standards applicable on the date of manufacture. Taken together, these conditions establish that the Surveillance Alternative would not conflict with applicable air quality attainment plans.

> **Impact AQ-1:** Based on the general inclusion of Surveillance Alternative emissions in the SIP emission inventory and the compliance with applicable air regulations, the Surveillance Alternative would not conflict with applicable air quality plans. Impacts would be **less than significant** and no mitigation is required**.**

Violate any stationary source air quality standard or contribute to an existing or projected air quality violation?

The Surveillance Alternative has the potential to emit regulated criteria pollutants, including O_3 precursors NO_X and VOCs, CO, SO_2, PM_{10}, and $PM_{2.5}$. Estimated peak daily emissions of each of these pollutants from all alternatives combined in the District are shown in Table 10-12 and are less than the daily thresholds shown in Table 10-3. Annual thresholds do not apply to estimated emissions shown in Table 10-6 because mosquito and vector control activities do not comprise a stationary source of air contaminants. Since mosquito and vector control activities are widely dispersed across a broad geographic area, no violation of CAAQS for CO would occur. Based on estimated peak daily emissions for each criteria pollutant and geographic dispersion, the Surveillance Alternative would not be the sole cause of a violation of either NAAQS or CAAQS.

> **Impact AQ-2:** Based on estimated daily emissions for each criteria pollutant, the Surveillance Alternative would not violate an ambient air quality standard. Impacts would be **less than significant** and no mitigation is required.

Result in a net increase of any criteria pollutant for which the project region is nonattainment under an applicable federal or state ambient air quality standard (including releasing emissions, which exceed quantitative thresholds for ozone precursors)?

As discussed in Section 10.1.6, the focus of this assessment is on regulated criteria pollutants for which the local air basin is in nonattainment. Nonattainment pollutants include O_3 precursors NO_X and VOCs, PM_{10}, and $PM_{2.5}$. Estimated peak daily emissions of each of these pollutants from all alternatives combined are shown in Table 10-12 and are less than the daily thresholds shown in Table 10-3. Annual thresholds do not apply to estimated emissions shown in Table 10-6 because mosquito and vector control activities do not comprise a stationary source of air contaminants. Based on estimated peak daily emissions for each criteria pollutant and geographic dispersion, the Surveillance Alternative would not result in a cumulatively considerable increase of nonattainment pollutants. Further, as discussed in Section 10.2.2.2, the primary sources of VOC emissions from mosquito abatement and vector control activities are from gasoline, diesel, and turbine engines used to conduct the Program. Other sources of

VOCs from materials would be relatively minor compared to engine exhaust and would be neither substantial nor cumulatively considerable.

> **Impact AQ-3:** Based on estimated daily emissions for each criteria pollutant, the Surveillance Alternative would not result in a cumulatively considerable increase of nonattainment pollutants. Impacts would be **less than significant** and no mitigation is required.

Expose sensitive receptors to substantial pollutant concentrations?

The Surveillance Alternative has the potential to emit regulated criteria pollutants, including O_3 precursors NO_X and VOCs, CO, SO_2, PM_{10}, and $PM_{2.5}$. Estimated peak daily emissions of each of these pollutants from all alternatives combined are shown in Table 10-12 and are less than the daily thresholds shown in Table 10-3. Annual thresholds do not apply to estimated emissions shown in Table 10-6 because mosquito and vector control activities do not comprise a stationary source of air contaminants. Since mosquito and vector control activities use relatively small amounts of diesel fuel (most equipment and vehicles are gasoline-powered), potential DPM emissions would be small, transient in nature, and dispersed over a wide geographic area. Thus, no significant risk to sensitive receptors would occur from DPM emissions (as PM_{10}). Based on estimated peak daily emissions for each criteria pollutant, the Surveillance Alternative would not be the sole cause of a violation of either NAAQS or CAAQS.

> **Impact AQ-4:** Based on the estimated daily emissions for each criteria pollutant, the Surveillance Alternative would not expose sensitive receptors to substantial pollutant concentrations. Impacts would be **less than significant** and no mitigation is required.

Create objectionable odors affecting a substantial number of people?

Certain VOCs, sulfur compounds, and chlorine compounds found in some pesticides, fumigants, and organochlorines emit characteristic odors when they evaporate (volatilize) into air, even at very low concentrations well within safety limits. The human sense of smell (olfactory system) is sensitive to these types of compounds as a warning mechanism, and some individuals are more sensitive than others. The Surveillance Alternative would not apply these types of odorous treatments, because it involves mostly field sampling and trapping activities. Thus, people would not be affected by objectionable odors.

> **Impact AQ-5:** The Surveillance Alternative would not subject people to objectionable odors. **No impact** would occur**.**

10.2.4 Physical Control Alternative

The Physical Control Alternative would be a continuation of existing activities the District currently practices using applicable techniques, equipment, vehicles, and watercraft. This alternative involves managing vector habitat using source control and permanent control methods that do not use biological agents or chemical pesticides, such as ditch maintenance, debris removal in natural channels, and blockage of access points. The environmental impact concerns are phrased as questions as follows for the Physical Control Alternative.

Conflict with or obstruct implementation of the applicable Air Quality Attainment Plan or Congestion Management Plan?

The emission source categories associated with the Physical Control Alternative include small equipment, portable equipment, offroad vehicles, onroad vehicles, and watercraft, all of which are mobile sources of nonattainment pollutants NO_X, VOCs, PM_{10}, and $PM_{2.5}$. As discussed in Section 10.1.6, these types of emission sources are included in the SIP emission inventory, required to meet CARB and USEPA nonroad and onroad emission standards applicable on the date of manufacture, and subject to PERP and ATCM as applicable. Taken together, these conditions establish that the Physical Control Alternative would not conflict with applicable air quality attainment plans.

Impact AQ-6: Based on the general inclusion of Physical Control Alternative emissions in the SIP emission inventory and the compliance with applicable air regulations, the Physical Control Alternative would not conflict with applicable air quality plans. Impacts would be **less than significant** and no mitigation is required.

Violate any stationary source air quality standard or contribute to an existing or projected air quality violation?

The Physical Control Alternative has the potential to emit regulated criteria pollutants, including O_3 precursors NO_X and VOCs, CO, SO_2, PM_{10}, and $PM_{2.5}$. Estimated peak daily emissions of each of these pollutants from all alternatives combined in the District are shown in Table 10-12 and are less than the daily thresholds shown in Table 10-3. Annual thresholds do not apply to estimated emissions shown in Table 10-7 because mosquito and vector control activities do not comprise a stationary source of air contaminants. Since mosquito and vector control activities are widely dispersed across a broad geographic area, no violation of CAAQS for CO would occur. Based on estimated peak daily emissions for each criteria pollutant and geographic dispersion, the Physical Control Alternative would not be the sole cause of a violation of either NAAQS or CAAQS.

Impact AQ-7: Based on estimated daily emissions for each criteria pollutant, the Physical Control Alternative would not violate an ambient air quality standard. Impacts would be **less than significant** and no mitigation is required.

Result in a net increase of any criteria pollutant for which the project region is nonattainment under an applicable federal or state ambient air quality standard (including releasing emissions, which exceed quantitative thresholds for ozone precursors)?

As discussed in Section 10.1.6, the focus of this assessment is on regulated criteria pollutants for which the local air basin is in nonattainment. Nonattainment pollutants include O_3 precursors NO_X and VOCs, PM_{10}, and $PM_{2.5}$. Estimated peak daily emissions of each of these pollutants from all alternatives combined in the District are shown in Table 10-12 and are less than the daily thresholds shown in Table 10-3. Annual thresholds do not apply to estimated emissions shown in Table 10-7 because mosquito and vector control activities do not comprise a stationary source of air contaminants. Based on estimated peak daily emissions for each criteria pollutant and geographic dispersion, the Physical Control Alternative would not result in a cumulatively considerable increase of nonattainment pollutants. Further, as discussed in Section 10.2.2.2, the primary sources of VOC emissions from mosquito abatement and vector control activities are from gasoline, diesel, and turbine engines used to conduct the Program. Other sources of VOCs from materials would be relatively minor compared to engine exhaust and would be neither substantial nor cumulatively considerable.

Impact AQ-8: Based on estimated daily emissions for each criteria pollutant, the Physical Control Alternative would not result in a cumulatively considerable increase of nonattainment pollutants. Impacts would be **less than significant** and no mitigation is required.

Expose sensitive receptors to substantial pollutant concentrations?

The Physical Control Alternative has the potential to emit regulated criteria pollutants, including O_3 precursors NO_X and VOCs, CO, SO_2, PM_{10}, and $PM_{2.5}$. Estimated peak daily emissions of each of these pollutants from the Physical Control Alternative in the individual District are shown in Table 10-13 and are less than the daily thresholds shown in Table 10-3. Annual thresholds do not apply to estimated emissions shown in Table 10-7 because mosquito and vector control activities do not comprise a stationary source of air contaminants. Since mosquito and vector control activities use relatively small amounts of diesel fuel (most equipment and vehicles are gasoline-powered), potential DPM emissions would be small, transient in nature, and dispersed over a wide geographic area. Thus, no significant risk to sensitive receptors would occur from DPM emissions (as PM_{10}). Based on estimated peak daily

emissions for each criteria pollutant, the Physical Control Alternative would not be the sole cause of a violation of either NAAQS or CAAQS.

> **Impact AQ-9:** Based on the estimated daily emissions for each criteria pollutant, the Physical Control Alternative would not expose sensitive receptors to substantial pollutant concentrations. Impacts would be **less than significant** and no mitigation is required.

Create objectionable odors affecting a substantial number of people?

Certain VOCs, sulfur compounds, and chlorine compounds found in some pesticides, fumigants, and organochlorines emit characteristic odors when they evaporate (volatilize) into air, even at very low concentrations well within safety limits. The human sense of smell (olfactory system) is sensitive to these types of compounds as a warning mechanism, and some individuals are more sensitive than others. The Physical Control Alternative would not apply these types of odorous chemical treatments. Thus, people would not be affected by objectionable odors.

> **Impact AQ-10:** The Physical Control Alternative would not subject people to objectionable odors. **No impact** would occur.

10.2.5 Vegetation Management Alternative

The Vegetation Management Alternative would be a continuation of existing activities the District currently practices using applicable techniques, equipment, vehicles, and watercraft. Vegetation management is used to reduce the habitat value for mosquitoes and other vectors and/or to provide access to sources of mosquito production. The District uses hand tools and sometimes heavy equipment to remove vegetation primarily in aquatic habitats. The District may also apply herbicides to remove vegetation. The District would employ BMPs listed in Section 10.2.2 to avoid or minimize impacts to air quality from herbicide use. The environmental impact concerns are phrased as questions as follows for the Vegetation Management Alternative.

Conflict with or obstruct implementation of the applicable Air Quality Attainment Plan or Congestion Management Plan?

The emission source categories associated with the Vegetation Management Alternative include small equipment, portable equipment, offroad vehicles, onroad vehicles, and watercraft, all of which are mobile sources of nonattainment pollutants NO_X, VOCs, PM_{10}, and $PM_{2.5}$. As discussed in Section 10.1.6, these types of emission sources are included in the SIP emission inventory, required to meet CARB and USEPA nonroad and onroad emission standards applicable on the date of manufacture, and subject to PERP and ATCM as applicable. Taken together, these conditions establish that the Vegetation Management Alternative would not conflict with applicable air quality attainment plans.

> **Impact AQ-11:** Based on the general inclusion of Vegetation Management Alternative emissions in the SIP emission inventory and the compliance with applicable air regulations, the Vegetation Management would not conflict with applicable air quality plans. Impacts would be **less than significant** and no mitigation is required.

Violate any stationary source air quality standard or contribute to an existing or projected air quality violation?

The Vegetation Management Alternative has the potential to emit regulated criteria pollutants, including O_3 precursors NO_X and VOCs, CO, SO_2, PM_{10}, and $PM_{2.5}$. Estimated peak daily emissions of each of these pollutants from all alternatives combined in the District are shown in Table 10-12 and are less than the daily thresholds shown in Table 10-3. Annual thresholds do not apply to estimated emissions shown in Table 10-8 because mosquito and vector control activities do not comprise a stationary source of air contaminants. Since mosquito and vector control activities are widely dispersed across a broad geographic area, no violation of CAAQS for CO would occur. Based on estimated peak daily emissions

for each criteria pollutant and geographic dispersion, the Vegetation Management Alternative would not be the sole cause of a violation of either NAAQS or CAAQS.

> **Impact AQ-12:** Based on estimated daily emissions for each criteria pollutant, the Vegetation Management Alternative would not violate an ambient air quality standard. Impacts would be **less than significant** and no mitigation is required.

Result in a net increase of any criteria pollutant for which the project region is nonattainment under an applicable federal or state ambient air quality standard (including releasing emissions, which exceed quantitative thresholds for ozone precursors)?

As discussed in Section 10.1.6, the focus of this assessment is on regulated criteria pollutants for which the local air basin is in nonattainment. Nonattainment pollutants include O_3 precursors NO_X and VOCs, PM_{10}, and $PM_{2.5}$. Estimated peak daily emissions of each of these pollutants from all alternatives combined in the District are shown in Table 10-12 and are less than the daily thresholds shown in Table 10-3. Annual thresholds do not apply to estimated emissions shown in Table 10-8 because mosquito and vector control activities do not comprise a stationary source of air contaminants. Based on estimated peak daily emissions for each criteria pollutant and geographic dispersion, the Vegetation Management Alternative would not result in a cumulatively considerable increase of nonattainment pollutants. Further, as discussed in Sections 10.2.2.2, the primary sources of VOC emissions from mosquito abatement and vector control activities are from gasoline, diesel, and turbine engines used to conduct the Program. Other sources of VOCs from herbicide materials would be relatively minor compared to engine exhaust and would be neither substantial nor cumulatively considerable.

> **Impact AQ-13:** Based on estimated daily emissions for each criteria pollutant, the Vegetation Management Alternative would not result in a cumulatively considerable increase of nonattainment pollutants. Impacts would be **less than significant** and no mitigation is required.

Expose sensitive receptors to substantial pollutant concentrations?

The Vegetation Management Alternative has the potential to emit regulated criteria pollutants, including O_3 precursors NO_X and VOCs, CO, SO_2, PM_{10}, and $PM_{2.5}$. Estimated peak daily emissions of each of these pollutants from all alternatives combined in the District are shown in Table 10-12 and are less than the daily thresholds shown in Table 10-3. Annual thresholds do not apply to estimated emissions shown in Table 10-8 because mosquito and vector control activities do not comprise a stationary source of air contaminants. Since mosquito and vector control activities use relatively small amounts of diesel fuel (most equipment and vehicles are gasoline-powered), potential DPM emissions would be small, transient in nature, and dispersed over a wide geographic area. Thus, no significant risk to sensitive receptors would occur from DPM emissions (as PM_{10}). Based on estimated peak daily emissions for each criteria pollutant, the Vegetation Management Alternative would not be the sole cause of a violation of either NAAQS or CAAQS.

> **Impact AQ-14:** Based on the estimated daily emissions for each criteria pollutant, the Vegetation Management Alternative would not expose sensitive receptors to substantial pollutant concentrations. Impacts would be **less than significant** and no mitigation is required.

Create objectionable odors affecting a substantial number of people?

Certain VOCs, sulfur compounds, and chlorine compounds found in some pesticides, fumigants, and organochlorines emit characteristic odors when they evaporate (volatilize) into air, even at very low concentrations well within safety limits. The human sense of smell (olfactory system) is sensitive to these types of compounds as a warning mechanism, and some individuals are more sensitive than others. The

Vegetation Management Alternative would not apply these types of odorous treatments; the herbicides used would not be odorous as well. Thus, people would not be affected by objectionable odors.

> **Impact AQ-15:** The Vegetation Management Alternative would not subject people to objectionable odors. **No impact** would occur.

10.2.6 Biological Control Alternative

The Biological Control Alternative would be a continuation of existing activities the District currently practices using applicable techniques, equipment, and vehicles. It involves the use of mosquito predators, mosquitofish (*Gambusia affinis*), with the biological pathogens evaluated under the Chemical Control Alternative. The environmental impact concerns are phrased as questions as follows for the Biological Control Alternative:

Conflict with or obstruct implementation of the applicable Air Quality Attainment Plan or Congestion Management Plan?

The emission source categories associated with the Biological Control Alternative include small equipment, portable equipment, offroad vehicles, and onroad vehicles, all of which are mobile sources of nonattainment pollutants NO_X, VOCs, PM_{10}, and $PM_{2.5}$. As discussed in Section 10.1.6, these types of emission sources are included in the SIP emission inventory, required to meet CARB and USEPA nonroad and onroad emission standards applicable on the date of manufacture, and subject to PERP and ATCM as applicable. Taken together, these conditions establish that the Biological Control Alternative would not conflict with applicable air quality attainment plans.

> **Impact AQ-16:** Based on the general inclusion of Biological Control Alternative emissions in the SIP emission inventory and the compliance with applicable air regulations, the Biological Control Alternative would not conflict with applicable air quality plans. Impacts would be **less than significant** and no mitigation is required.

Violate any stationary source air quality standard or contribute to an existing or projected air quality violation?

The Biological Control Alternative has the potential to emit regulated criteria pollutants, including O_3 precursors NO_X and VOCs, CO, SO_2, PM_{10}, and $PM_{2.5}$. Estimated peak daily emissions of each of these pollutants from all alternatives combined in the District are shown in Table 10-12 and are less than the daily thresholds shown in Table 10-3. Annual thresholds do not apply to estimated emissions shown in Table 10-9 because mosquito and vector control activities do not comprise a stationary source of air contaminants. Since mosquito and vector control activities are widely dispersed across a broad geographic area, no violation of CAAQS for CO would occur. Based on estimated peak daily emissions for each criteria pollutant and geographic dispersion, the Biological Control Alternative would not be the sole cause of a violation of either NAAQS or CAAQS.

> **Impact AQ-17:** Based on estimated daily emissions for each criteria pollutant, the Biological Control Alternative would not violate an ambient air quality standard. Impacts would be **less than significant** and no mitigation is required.

Result in a net increase of any criteria pollutant for which the project region is nonattainment under an applicable federal or state ambient air quality standard (including releasing emissions, which exceed quantitative thresholds for ozone precursors)?

As discussed in Section 10.1.6, the focus of this assessment is on regulated criteria pollutants for which the local air basin is in nonattainment. Nonattainment pollutants include O_3 precursors NO_X and VOCs, PM_{10}, and $PM_{2.5}$. Estimated peak daily emissions of each of these pollutants from all alternatives combined in the District are shown in Table 10-12 and are less than the daily thresholds shown in Table 10-3. Annual thresholds do not apply to estimated emissions shown in Table 10-9 because

mosquito and vector control activities do not comprise a stationary source of air contaminants. Based on estimated peak daily emissions for each criteria pollutant and geographic dispersion, the Biological Control Alternative would not result in a cumulatively considerable increase of nonattainment pollutants. Further, as discussed in Section 10.2.2.2, the primary sources of VOC emissions from mosquito abatement and vector control activities are from gasoline, diesel, and turbine engines used to conduct the Program. Other sources of VOCs from materials would be relatively minor compared to engine exhaust and would be neither substantial nor cumulatively considerable.

> **Impact AQ-18:** Based on estimated daily emissions for each criteria pollutant, the Biological Control Alternative would not result in a cumulatively considerable increase of nonattainment pollutants. Impacts would be **less than significant** and no mitigation is required.

Expose sensitive receptors to substantial pollutant concentrations?

The Biological Control Alternative has the potential to emit regulated criteria pollutants, including O_3 precursors NO_X and VOCs, CO, SO_2, PM_{10}, and $PM_{2.5}$. Estimated peak daily emissions of each of these pollutants from all alternatives combined in the District are shown in Table 10-12 and are less than the daily thresholds shown in Table 10-3. Annual thresholds do not apply to estimated emissions shown in Table 10-9 because mosquito and vector control activities do not comprise a stationary source of air contaminants. Since mosquito and vector control activities use relatively small amounts of diesel fuel (most equipment and vehicles are gasoline-powered), potential DPM emissions would be small, transient in nature, and dispersed over a wide geographic area. Thus, no significant risk to sensitive receptors would occur from DPM emissions (as PM_{10}). Based on estimated peak daily emissions for each criteria pollutant, the Biological Control Alternative would not be the sole cause of a violation of either NAAQS or CAAQS.

> **Impact AQ-19:** Based on the estimated daily emissions for each criteria pollutant, the Biological Control Alternative would not expose sensitive receptors to substantial pollutant concentrations. Impacts would be **less than significant** and no mitigation is required.

Create objectionable odors affecting a substantial number of people?

Certain VOCs, sulfur compounds, and chlorine compounds found in some pesticides emit characteristic odors when they evaporate (volatilize) into air, even at very low concentrations well within safety limits. The human sense of smell (olfactory system) is sensitive to these types of compounds as a warning mechanism, and some individuals are more sensitive than others. The Biological Control Alternative would not apply these types of odorous treatments. Thus, people would not be subjected to objectionable odors.

> **Impact AQ-20:** The Biological Control Alternative would not subject people to objectionable odors. **No impact** would occur.

10.2.7 Chemical Control Alternative

The Chemical Control Alternative would be a continuation of existing activities the District currently practices using applicable techniques, equipment, vehicles, watercraft, and aircraft. It involves the application of insecticides to reduce populations of vector species. The District employs BMPs listed in Section 10.2.2 to avoid or minimize impacts to air quality from pesticide use. The environmental impact concerns are phrased as questions as follows for the Chemical Control Alternative.

Conflict with or obstruct implementation of the applicable Air Quality Attainment Plan or Congestion Management Plan?

The emission source categories associated with the Chemical Control Alternative include small equipment, portable equipment, offroad vehicles, onroad vehicles, watercraft, and aircraft all of which are mobile sources of nonattainment pollutants NO_X, VOCs, PM_{10}, and $PM_{2.5}$. As discussed in Section 10.1.6, these types of emission sources are included in the SIP emission inventory, required to meet CARB and USEPA nonroad and onroad emission standards applicable on the date of manufacture, and subject to

PERP and ATCM as applicable. Taken together, these conditions establish that the Chemical Control Alternative would not conflict with applicable air quality attainment plans.

> **Impact AQ-21:** Based on the general inclusion of Chemical Control Alternative emissions in the SIP emission inventory and the compliance with applicable air regulations, the Chemical Control Alternative would not conflict with applicable air quality plans. Impacts would be **less than significant** and no mitigation is required.

Violate any stationary source air quality standard or contribute to an existing or projected air quality violation?

The Chemical Control Alternative has the potential to emit regulated criteria pollutants, including O_3 precursors NO_X and VOCs, CO, SO_2, PM_{10}, and $PM_{2.5}$. Estimated peak daily emissions of each of these pollutants from all alternatives combined in the District are shown in Table 10-12 and are less than the daily thresholds shown in Table 10-3. Annual thresholds do not apply to estimated emissions shown in Table 10-10 because mosquito and vector control activities do not comprise a stationary source of air contaminants. Since mosquito and vector control activities are widely dispersed across a broad geographic area, no violation of CAAQS for CO would occur. Based on estimated peak daily emissions for each criteria pollutant and geographic dispersion, the Chemical Control Alternative would not be the sole cause of a violation of either NAAQS or CAAQS.

> **Impact AQ-22:** Based on estimated daily emissions for each criteria pollutant, the Chemical Control Alternative would not violate an ambient air quality standard. Impacts would be **less than significant** and no mitigation is required.

Result in a net increase of any criteria pollutant for which the project region is nonattainment under an applicable NAAQS or CAAQS (including releasing emissions, which exceed quantitative thresholds for O_3 precursors)?

As discussed in Section 10.1.6, the focus of this assessment is on regulated criteria pollutants for which the local air basin is in nonattainment. Nonattainment pollutants include O_3 precursors NO_X and VOCs, PM_{10}, and $PM_{2.5}$. Estimated peak daily emissions of each of these pollutants from all alternatives combined in the District are shown in Table 10-12 and are less than the daily thresholds shown in Table 10-3. Annual thresholds do not apply to estimated emissions shown in Table 10-10 because mosquito and vector control activities do not comprise a stationary source of air contaminants. Based on estimated peak daily emissions for each criteria pollutant and geographic dispersion, the Chemical Control Alternative would not result in a cumulatively considerable increase of nonattainment pollutants. Further, as discussed in Section 10.2.2.2, the primary sources of VOC emissions from mosquito abatement and vector control activities are from gasoline, diesel, and turbine engines used to conduct the Program. Other sources of VOCs from pesticide materials would be relatively minor compared to engine exhaust and would be neither substantial nor cumulatively considerable.

> **Impact AQ-23:** Based on estimated daily emissions for each criteria pollutant, the Chemical Control Alternative would not result in a cumulatively considerable increase of nonattainment pollutants**.** Impacts would be **less than significant** and no mitigation is required.

Expose sensitive receptors to substantial pollutant concentrations?

The Chemical Control Alternative has the potential to emit regulated criteria pollutants, including O_3 precursors NO_X and VOCs, CO, SO_2, PM_{10}, and $PM_{2.5}$. Estimated peak daily emissions of each of these pollutants from all alternatives combined in the District are shown in Table 10-12 and are less than the daily thresholds shown in Table 10-3. Annual thresholds do not apply to estimated emissions shown in Table 10-10 because mosquito and vector control activities do not comprise a stationary source of air contaminants. Since mosquito and vector control activities use relatively small amounts of diesel fuel (most equipment and vehicles are gasoline-powered), potential DPM emissions would be small, transient in

nature, and dispersed over a wide geographic area. Thus, no significant risk to sensitive receptors would occur from DPM emissions (as PM_{10}). Based on estimated peak daily emissions for each criteria pollutant, the Chemical Control Alternative would not be the sole cause of a violation of either NAAQS or CAAQS.

> **Impact AQ-24:** Based on the estimated daily emissions for each criteria pollutant, the Chemical Control Alternative would not expose sensitive receptors to substantial pollutant concentrations**.** Impacts would be **less than significant** and no mitigation is required.

Create objectionable odors affecting a substantial number of people?

Certain VOCs, sulfur compounds, and chlorine compounds found in some pesticides, fumigants, and organochlorines emit characteristic odors when they evaporate (volatilize) into air, even at very low concentrations well within safety limits. Pesticides proposed for future use emit phenols (e.g., deltamethrin, etofenprox, permethrin, and resmethrin). Materials such as Bti in liquid form and the adulticides pyrethrin and permethrin have an odor. Due to limited applicability, small quantities of these types of substances are typically used.

The human sense of smell (olfactory system) is sensitive to these types of compounds as a warning mechanism, and some individuals are more sensitive than others. The Chemical Control Alternative would apply certain types of odorous treatments using hydraulic spraying and atomizing (fogging), which could result in drift of small droplets and gaseous vapors. Depending on atmospheric conditions (i.e., wind direction, wind speed, stability class), this drift could subject people to objectionable odors near a treatment area. Without site-specific information, it cannot be determined whether an objectionable odor may persist downwind of a particular treatment area; therefore, an application containing an odorous compound may impact an undefined number people for an undefined period of time including recreationists and residents. The materials have been used in the current Program, and people have not complained about odors. However, it is possible that complaints could occur in the future.

> **Impact AQ-25:** The Chemical Control Alternative could subject people to objectionable odors. Impacts could be **potentially significant but mitigable**, even with BMPs implemented.

To mitigate Impact AQ-25, the District and its contractors may implement any of the following measures as applicable to the specific application situation to reduce drift towards human populations/residences from the ground and aerial applications of odorous treatment compounds:

> Mitigation Measure AQ-25a: Whenever possible and practicable, defer application of treatment compounds until such time that favorable wind conditions would reduce or avoid the risk of drift into populated areas.
>
> Mitigation Measure AQ-25b: Utilize equipment such as wind meters and global positioning system (GPS) tracking when applicable that assist in documenting site-specific compliance with all label requirements for drift mitigation.
>
> Mitigation Measure AQ-25c: Use precision application technology to reduce drift and the total amount of material applied. This measure can include (1) Precision guidance systems that minimize ground or aerial spray overlap (e.g., GPS and Real Time Kinetics – GPS/RTK) and (2) Computer-guided application systems that integrate real-time meteorological data and computer model guidance to reduce drift from aerial application (e.g., trade names “AIMMS,” “Wingman™ GX,” and “NextStar™ Flow Control”).

Use of any one of these measures would reduce the impact to **less than significant**.

10.2.8 Other Nonchemical Control/Trapping Alternative

As applicable, the Other Nonchemical Control/Trapping Alternative would be the District conducting limited trapping activities using applicable techniques, existing equipment, and existing vehicles. An example of these types of activities would be trapping of rodents and/or yellow jackets to determine presence in an area. The environmental impact concerns are phrased as questions as follows for the Other Nonchemical Control/Trapping Alternative.

Conflict with or obstruct implementation of the applicable Air Quality Attainment Plan or Congestion Management Plan?

The emission source categories associated with the Other Nonchemical Control/Trapping Alternative include small equipment, portable equipment, offroad vehicles, onroad vehicles, and watercraft, all of which are mobile sources of nonattainment pollutants NO_X, VOCs, PM_{10}, and $PM_{2.5}$. As discussed in Section 10.1.6, these types of emission sources are included in the SIP emission inventory, required to meet CARB and USEPA nonroad and onroad emission standards applicable on the date of manufacture, and subject to PERP and ATCM as applicable. Taken together, these conditions establish that the Other Nonchemical Control/Trapping Alternative would not conflict with applicable air quality attainment plans.

> **Impact AQ-26:** Based on the general inclusion of Other Nonchemical Control/Trapping Alternative emissions in the SIP emission inventory and the compliance with applicable air regulations, the Other Nonchemical Control/Trapping Alternative would not conflict with applicable air quality plans**.** Impacts would be **less than significant** and no mitigation is required.

Violate any stationary source air quality standard or contribute to an existing or projected air quality violation?

The Other Nonchemical Control/Trapping Alternative has the potential to emit regulated criteria pollutants, including O_3 precursors NO_X and VOCs, CO, SO_2, PM_{10}, and $PM_{2.5}$. Estimated peak daily emissions of each of these pollutants from all alternatives combined in the District are shown in Table 10-12 and are less than the daily thresholds shown in Table 10-3. Annual thresholds do not apply to estimated emissions shown in Table 10-11 because mosquito and vector control activities do not comprise a stationary source of air contaminants. Since mosquito and vector control activities are widely dispersed across a broad geographic area, no violation of CAAQS for CO would occur. Based on estimated peak daily emissions for each criteria pollutant and geographic dispersion, the Other Nonchemical Control/Trapping Alternative would not be the sole cause of a violation of either NAAQS or CAAQS.

> **Impact AQ-27:** Based on estimated daily emissions for each criteria pollutant, the Other Nonchemical Control/Trapping Alternative would not violate an ambient air quality standard. Impacts would be **less than significant** and no mitigation is required.

Result in a net increase of any criteria pollutant for which the project region is nonattainment under an applicable federal or state ambient air quality standard (including releasing emissions, which exceed quantitative thresholds for ozone precursors)?

As discussed in Section 10.1.6, the focus of this assessment is on regulated criteria pollutants for which the local air basin is in nonattainment. Nonattainment pollutants include O_3 precursors NO_X and VOCs, PM_{10}, and $PM_{2.5}$. Estimated peak daily emissions of each of these pollutants from all alternatives combined in the District are shown in Table 10-12 and are less than the daily thresholds shown in Table 10-3. Annual thresholds do not apply to estimated emissions shown in Table 10-11 because mosquito and vector control activities do not comprise a stationary source of air contaminants. Based on estimated peak daily emissions for each criteria pollutant and geographic dispersion, the Other Nonchemical Control/Trapping Alternative would not result in a cumulatively considerable increase of nonattainment pollutants. Further, as discussed in Section 10.2.2.2, the primary sources of VOC

emissions from mosquito abatement and vector control activities are from gasoline, diesel, and turbine engines used to conduct the Program. Other sources of VOCs from materials would be relatively minor compared to engine exhaust and would be neither substantial nor cumulatively considerable.

> **Impact AQ-28:** Based on estimated daily emissions for each criteria pollutant, the Other Nonchemical Control/Trapping Alternative would not result in a cumulatively considerable increase of nonattainment pollutants. Impacts would be **less than significant** and no mitigation is required.

Expose sensitive receptors to substantial pollutant concentrations?

The Other Nonchemical Control/Trapping Alternative has the potential to emit regulated criteria pollutants, including O_3 precursors NO_X and VOCs, CO, SO_2, PM_{10}, and $PM_{2.5}$. Estimated peak daily emissions of each of these pollutants from all alternatives combined in the District are shown in Table 10-12 and are less than the daily thresholds shown in Table 10-3. Annual thresholds do not apply to estimated emissions shown in Table 10-11 because mosquito and vector control activities do not comprise a stationary source of air contaminants. Since mosquito and vector control activities use relatively small amounts of diesel fuel (most equipment and vehicles are gasoline-powered), potential DPM emissions would be small, transient in nature, and dispersed over a wide geographic area. Thus, no significant risk to sensitive receptors would occur from DPM emissions (as PM_{10}). Based on estimated peak daily emissions for each criteria pollutant, the Other Nonchemical Control/Trapping Alternative would not be the sole cause of a violation of either NAAQS or CAAQS.

> **Impact AQ-29:** Based on the estimated daily emissions for each criteria pollutant, the Other Nonchemical Control/Trapping Alternative would not expose sensitive receptors to substantial pollutant concentrations. Impacts would be **less than significant** and no mitigation is required.

Create objectionable odors affecting a substantial number of people?

Certain VOCs, sulfur compounds, and chlorine compounds found in some pesticides emit characteristic odors when they evaporate (volatilize) into air, even at very low concentrations well within safety limits. The human sense of smell (olfactory system) is sensitive to these types of compounds as a warning mechanism, and some individuals are more sensitive than others. The Other Nonchemical Control/Trapping Alternative would not apply these types of odorous treatments. Thus, people would not be subjected to objectionable odors.

> **Impact AQ-30:** The Other Nonchemical Control/Trapping Alternative would not subject people to objectionable odors. **No impact** would occur.

10.2.9 Cumulative Impacts

In developing thresholds of significance, BAAQMD considered the emission levels for which a project's individual emissions would be cumulatively considerable. Therefore, if a project would result in an increase in emissions at or above applicable mass thresholds, then it would be deemed to have a cumulatively considerable impact. Conversely, if a project would not exceed the significance thresholds, then its emissions would not be cumulatively considerable. (BAAQMD 2011)

Cumulative impacts to regional air quality are discussed in Section 13.8. The majority of air districts in California, including BAAQMD, NSCAPCD, YSAQMD, MCAQMD, and LCAQMD assume that if project-level emissions do not exceed significance thresholds, and no closely related project exists, then a project would not have a cumulatively considerable impact on air quality. All of the Program alternative emissions (separately and combined for the District's entire Program) would be below the significance thresholds for criteria pollutant emissions. In summary, **the incremental impacts on air quality from the Program**

alternatives are not individually significant nor are they cumulatively considerable. Therefore, cumulative impacts to regional air quality are less than significant.

Concerning the cumulative impact of pesticide use by the District when combined with pesticide use by agriculture, the CDPR restricts use of many agricultural pesticide products that are high in VOCs to comply with the CAA. Statewide use of agricultural pesticides on commercial crops accounts for approximately 2 percent of all VOCs produced in the state, while the VOC emissions of pesticides and herbicides the District typically uses for vector control are minimal to not significant. State restrictions described above include some high-VOC products containing abamectin, chlorpyrifos (not used extensively), gibberellins, or oxyfluorfen (used primarily on some Central California crops), and this concern should not impact District use of pesticides for vector control. (CDPR 2014c)

10.2.10 Environmental Impacts Summary

Table 10-19 presents a summary of air quality impacts associated with the six alternatives in comparison to existing emissions inventories and conditions. The air quality impact callouts correspond to those in Sections 10.2.3 through 10.2.8.

Table 10-19 Summary of Alternative Air Quality Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Effects on Air Quality						
Impact AQ-1: Based on the general inclusion of Surveillance Alternative emissions in the SIP emission inventory and the compliance with applicable air regulations, the Surveillance Alternative would not conflict with applicable air quality plans. Impacts would be **less than significant** and no mitigation is required**.**	LS	na	na	na	na	na
Impact AQ-2: Based on estimated daily emissions for each criteria pollutant, the Surveillance Alternative would not violate an ambient air quality standard. Impacts would be **less than significant** and no mitigation is required.	LS	na	na	na	na	na
Impact AQ-3: Based on estimated daily emissions for each criteria pollutant, the Surveillance Alternative would not result in a cumulatively considerable increase of nonattainment pollutants. Impacts would be **less than significant** and no mitigation is required.	LS	na	na	na	na	na
Impact AQ-4: Based on the estimated daily emissions for each criteria pollutant, the Surveillance Alternative would not expose sensitive receptors to substantial pollutant concentrations. Impacts would be **less than significant** and no mitigation is required.	LS	na	na	na	na	na
Impact AQ-5: The Surveillance Alternative would not subject people to objectionable odors. **No impact** would occur.	N	na	na	na	na	na
Impact AQ-6: Based on the general inclusion of Physical Control Alternative emissions in the SIP emission inventory and the compliance with applicable air regulations, the Physical Control Alternative would not conflict with applicable air quality plans. Impacts would be **less than significant** and no mitigation is required.	na	LS	na	na	na	na

Table 10-19 Summary of Alternative Air Quality Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact AQ-7: Based on estimated daily emissions for each criteria pollutant, the Physical Control Alternative would not violate an ambient air quality standard. Impacts would be **less than significant** and no mitigation is required.	na	LS	na	na	na	na
Impact AQ-8: Based on estimated daily emissions for each criteria pollutant, the Physical Control Alternative would not result in a cumulatively considerable increase of nonattainment pollutants. Impacts would be **less than significant** and no mitigation is required.	na	LS	na	na	na	na
Impact AQ-9: Based on the estimated daily emissions for each criteria pollutant, the Physical Control Alternative would not expose sensitive receptors to substantial pollutant concentrations. Impacts would be **less than significant** and no mitigation is required.	na	LS	na	na	na	na
Impact AQ-10: The Physical Control Alternative would not subject people to objectionable odors. **No impact** would occur.	na	N	na	na	na	na
Impact AQ-11: Based on the general inclusion of Vegetation Management Alternative emissions in the SIP emission inventory and the compliance with applicable air regulations, the Vegetation Management would not conflict with applicable air quality plans. Impacts would be **less than significant** and no mitigation is required.	na	na	LS	na	na	na
Impact AQ-12: Based on estimated daily emissions for each criteria pollutant, the Vegetation Management Alternative would not violate an ambient air quality standard. Impacts would be **less than significant** and no mitigation is required.	na	na	LS	na	na	na
Impact AQ-13: Based on estimated daily emissions for each criteria pollutant, the Vegetation Management Alternative would not result in a cumulatively considerable increase of nonattainment pollutants. Impacts would be **less than significant** and no mitigation is required.	na	na	LS	na	na	na

Table 10-19 Summary of Alternative Air Quality Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact AQ-14: Based on the estimated daily emissions for each criteria pollutant, the Vegetation Management Alternative would not expose sensitive receptors to substantial pollutant concentrations. Impacts would be **less than significant** and no mitigation is required.	na	na	LS	na	na	na
Impact AQ-15: The Vegetation Management Alternative would not subject people to objectionable odors. **No impact** would occur.	na	na	N	na	na	na
Impact AQ-16: Based on the general inclusion of Biological Control Alternative emissions in the SIP emission inventory and the compliance with applicable air regulations, the Biological Control Alternative would not conflict with applicable air quality plans. Impacts would be **less than significant** and no mitigation is required.	na	na	na	LS	na	na
Impact AQ-17: Based on estimated daily emissions for each criteria pollutant, the Biological Control Alternative would not violate an ambient air quality standard. Impacts would be **less than significant** and no mitigation is required.	na	na	na	LS	na	na
Impact AQ-18: Based on estimated daily emissions for each criteria pollutant, the Biological Control Alternative would not result in a cumulatively considerable increase of nonattainment pollutants**.** Impacts would be **less than significant** and no mitigation is required.	na	na	na	LS	na	na
Impact AQ-19: Based on the estimated daily emissions for each criteria pollutant, the Biological Control Alternative would not expose sensitive receptors to substantial pollutant concentrations. Impacts would be **less than significant** and no mitigation is required.	na	na	na	LS	na	na
Impact AQ-20: The Biological Control Alternative would not subject people to objectionable odors. **No impact** would occur.	na	na	na	N	na	na

Table 10-19 Summary of Alternative Air Quality Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact AQ-21: Based on the general inclusion of Chemical Control Alternative emissions in the SIP emission inventory and the compliance with applicable air regulations, the Chemical Control Alternative would not conflict with applicable air quality plans. Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	LS	na
Impact AQ-22: Based on estimated daily emissions for each criteria pollutant, the Chemical Control Alternative would not violate an ambient air quality standard. Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	LS	na
Impact AQ-23: Based on estimated daily emissions for each criteria pollutant, the Chemical Control Alternative would not result in a cumulatively considerable increase of nonattainment pollutants**.** Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	LS	na
Impact AQ-24: Based on the estimated daily emissions for each criteria pollutant, the Chemical Control Alternative would not expose sensitive receptors to substantial pollutant concentrations**.** Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	LS	na
Impact AQ-25: The Chemical Control Alternative could subject people to objectionable odors. Impacts could be **potentially significant but mitigable**, even with BMPs implemented.	na	na	na	na	SM	na
Impact AQ-26: Based on the general inclusion of Other Nonchemical Control/Trapping Alternative emissions in the SIP emission inventory and the compliance with applicable air regulations, the Other Nonchemical Control/Trapping Alternative would not conflict with applicable air quality plans**.** Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	na	LS

Table 10-19 Summary of Alternative Air Quality Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact AQ-27: Based on estimated daily emissions for each criteria pollutant, the Other Nonchemical Control/Trapping Alternative would not violate an ambient air quality standard. Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	na	LS
Impact AQ-28: Based on estimated daily emissions for each criteria pollutant, the Other Nonchemical Control/Trapping Alternative would not result in a cumulatively considerable increase of nonattainment pollutants. Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	na	LS
Impact AQ-29: Based on the estimated daily emissions for each criteria pollutant, the Other Nonchemical Control/Trapping Alternative would not expose sensitive receptors to substantial pollutant concentrations. Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	na	LS
Impact AQ-30: The Other Nonchemical Control/Trapping Alternative would not subject people to objectionable odors. **No impact** would occur.	na	na	na	na	na	N

Sources: BAAQMD 1999; Hare and Springer 1973; CARB 2008a; USEPA 1991d, 2011a, 2011b, 2012c

LS = Less-than-significant impact

N = No impact

na = Not applicable

SM = Potentially significant but mitigable impact

SU = Significant and unavoidable impact

10.2.11 Mitigation and Monitoring

Except for mitigated odor impacts under the Chemical Control Alternative (Impact AQ-25), all other impacts are either less than significant (LS) or no impact (N) and require no mitigation. The District will reduce small impacts even further (under Impacts AQ-2/3, AQ-7/8, AQ-12/13, AQ-17/18, AQ-22/23, and AQ-27/28), as described below.

Notwithstanding significance, BMPs pursuant to California Air Toxics Control Measures (13 CCR 2485) and In-Use Off-Road Diesel Vehicle Regulations (13 CCR 2449 et seq.) will also minimize criteria pollutant and GHG emissions from diesel and gasoline engine exhaust. The District and its contractors will implement the following BMPs as part of the Program:

> Idling times shall be minimized either by shutting equipment and vehicles off when not in use or reducing the maximum idling time to 5 minutes. Clear signage shall be provided for workers at all access points.

> Correct tire inflation shall be maintained in accordance with manufacturer's specifications on wheeled equipment and vehicles to prevent excessive rolling resistance.

> All equipment and vehicles shall be maintained and properly tuned in accordance with manufacturer's specifications. All equipment shall be checked by a certified visible emissions evaluator if visible emissions are apparent to onsite staff.

Also, where practicable and available, the Program will use alternatively fueled equipment, such as compressed natural gas (CNG), liquefied natural gas (LNG), liquefied petroleum/propane gas (LPG), or biodiesel.

To mitigate Impact AQ-25, the District and its contractors may implement any of the following measures as applicable to reduce drift from the ground and aerial application of treatment compounds:

Mitigation Measure AQ-25a: When possible, defer application of treatment compounds until such time that favorable wind conditions would reduce or avoid the risk of drift into populated areas.

> Location: Areas to receive treatment with pesticides that are near residential and commercial land uses

> Monitoring/Reporting Action: District staff to check current land use maps or aerial photos prior to treatments

> Effectiveness Criteria: Document odor complaints from the public

> Responsible Agency: District

> Timing: Prior to chemical treatments

Mitigation Measure AQ-25b: Use weather forecasts, real-time observations, wind meters, and GPS equipment when applicable to assist in documenting site-specific compliance with all label requirements for drift mitigation.

> Location: Areas to receive treatment with pesticides that are near residential and commercial land uses

> Monitoring/Reporting Action: District staff to check current land use maps or aerial photos prior to treatments

> Effectiveness Criteria: Document odor complaints from the public

> Responsible Agency: District

> Timing: Prior to chemical treatments

Mitigation Measure AQ-25c: Use precision application technology to reduce drift and the total amount of material applied. This measure can include (1) precision guidance systems that minimize ground or aerial spray overlap (e.g., GPS and Real Time Kinetics – GPS/RTK) and (2) computer-guided application systems that integrate real-time meteorological data and computer model guidance to reduce drift from aerial application (e.g., trade names “AIMMS,” “Wingman™ GX,” and “NextStar™ Flow Control”). This technology is possible with equipment such as the helicopter/aircraft and application of adulticides with the larger truck-mounted ULV foggers but not for small site-specific applications by hand equipment or ATVs. The District currently outfits all ATVs with GPS guidance systems. These ATV applications are typically low volume and staff is trained (via CDPH) to make decisions in the field to correctly and accurately apply materials. This shift is not difficult at the slow speeds involved in these applications. District also has physical site information (e.g., size of treatment area) to assist in precision of the application.

> Location: Areas to receive treatment with pesticides that are near residential and commercial land uses

> Monitoring/Reporting Action: District staff to check current land use maps or aerial photos prior to treatments

> Effectiveness Criteria: Document odor complaints from the public

> Responsible Agency: District

> Timing: Prior to chemical treatments

11 Greenhouse Gases and Climate Change

This chapter provides an overview of the environmental setting for greenhouse gases (GHGs) and climate change, based on Appendix C, *Air Quality and Greenhouse Gases Technical Report*. The American Meteorological Society refers to climate change as any systematic change in the long-term statistics of climate elements (such as temperature, pressure, or winds) sustained over several decades or longer. The Society also indicates that climate change may be due to natural external forces, such as changes in solar emission or slow changes in the Earth's orbital elements; natural internal processes of the climate system; or anthropogenic forcing (AMS 2014). The climate system can be influenced by changes in the concentration of various GHGs in the atmosphere that affect the Earth's absorption of radiation. This chapter concludes with an evaluation of the Proposed Program's contribution to GHG emissions and conclusions of environmental impact. It concludes with a discussion of how the District will reduce small impacts even further using BMPs.

11.1 Environmental Setting

11.1.1 Global Climate Change

Climate change refers to any measurable alteration of climate lasting for an extended period of time – several decades or longer – and includes recordable changes in temperature, precipitation, or wind patterns. The average temperature of the Earth has increased about 0.7 to 1.5°F (0.4 to 0.8°C) over the past century, and is projected to rise another 2 to 11.5°F (1.1 to 6.4°C) over the next 100 years (IPCC 2001; USEPA 2012b). Seemingly, small changes in the average temperature of the planet can translate to large and potentially hazardous shifts in climate and weather. Climate change is suspected as the cause of changes in rainfall amounts and distribution that can result in flooding, droughts, or more frequent and severe heat waves. Also, oceans are warming and becoming more acidic, polar ice caps are melting, glaciers are receding, and sea levels are rising due to thermal expansion and ice loss. Long-term studies indicate that ocean surface temperatures have been rising at an average rate of 0.13°F (0.07°C) per decade and since 1901, average sea level has increased by about 8 inches (20 centimeters) during the same period, and average pH has decreased (acidified) by about 0.05 pH units since the mid-1980s. Late summer Arctic Ocean sea ice coverage has decreased by half since 1979, and glaciers have receded and lost significant mass since the 1970s (USEPA 2012b). As climate change progresses in the coming decades, it will likely present challenges to society and the environment.

11.1.1.1 Local Climate

The Program Area climate is characterized by moderately wet winters and dry summers. For the region including the Marin-Sonoma Mosquito Vector Control District (MSMVCD, the District), about 90 percent of the annual total rainfall is received in the November through April period. Between June and September, normal rainfall is typically less than 0.6 inch (1.5 centimeters). Temperatures in the Program Area average about 60°F (15°C) annually, with average summer highs in the 70 to 80°F (21 to 27°C) range and average winter lows in the 40 to 50°F (4 to 10°C) range. Precipitation averages about 23 inches (58 centimeters) per year, although annual precipitation can vary significantly from year to year. Annual average wind speeds in the Program Area are about 8 miles per hour (3.6 meters per second). The predominant direction of air pollution transport in the Program Area is inland from the coastal areas (BAAQMD 2010a; World Climate 2012; NOAA 2008).

11.1.2 The Greenhouse Effect

Over the past century, human activities have released large amounts of carbon dioxide (CO_2) and other GHGs into the atmosphere. The majority of GHGs are the by-product of burning fossil fuels to release

energy in the form of heat, although deforestation, industrial processes, and some agricultural practices also emit GHGs into the atmosphere. GHGs trap solar energy in the atmosphere and cause it to warm. This phenomenon is called the greenhouse effect and is necessary to support life on Earth; however, excessive buildup of GHGs can change Earth's climate and result in undesirable effects on ecosystems, which affect human health and welfare. (USEPA 2012b)

In its *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2012* (USEPA 2012c, 2014b), the USEPA provides summary information on the work of the United Nations Framework Convention on Climate Change (UNFCCC 2009) and the Intergovernmental Panel on Climate Control (IPCC 1990-2013); key information from that report is summarized below – more details may be found in the cited source documents.

The UNFCCC defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" (UNFCCC 2009). In its *Second Assessment Report* of the science of climate change, the IPCC concluded "human activities are changing the atmospheric concentrations and distributions of greenhouse gases and aerosols" (IPCC 1995). These changes can produce a radiative forcing by changing either the reflection or absorption of solar radiation, or the emission and absorption of terrestrial radiation." Building on this conclusion, the IPCC *Third Assessment Report* (IPCC 2001) asserted "concentrations of atmospheric greenhouse gases and their radiative forcing have continued to increase as a result of human activities."

The IPCC reports the global average surface temperature of the Earth has increased by 1.1 ± 0.4°F (0.6 ± 0.2°C) over the 20th century. This value is about 0.27°F (0.15°C) larger than that estimated by the Second Assessment Report, which reported for the period up to 1994, "owing to the relatively high temperatures of the additional years (1995 to 2000) and improved methods of processing the data."

While the *Second Assessment Report* (1995) concluded, "the balance of evidence suggests there is a discernible human influence on global climate," the *Third Assessment Report* (2001) more directly connects the influence of human activities on climate. IPCC concluded, "In light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations."

In its most recent *Fourth Assessment Report* (2007), IPCC stated warming of Earth's climate is unequivocal, and that warming is very likely attributable to increases in atmospheric GHGs caused by human activities (IPCC 2007). IPCC further stated changes in many physical and biological systems, such as increases in global temperatures, more frequent heat waves, rising sea levels, coastal flooding, loss of wildlife habitat, spread of infectious disease, and other potential environmental impacts, are linked to changes in the climate system, and some changes might be irreversible.

In its newly released *Fifth Assessment Report* (2013), the IPCC reinforced evidence for warming of the climate system since the 1950s. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and GHG concentrations have increased. Each of the last 3 decades has been successively warmer at the Earth's surface than any preceding decade since 1850. In the Northern Hemisphere, 1983 to 2012 was likely the warmest 30-year period of the last 1,400 years. IPCC reports (IPCC 2013):

> The atmospheric concentrations of CO_2, methane (CH_4), and nitrous oxide (N_2O) have all increased since 1750 due to human activity. In 2011, average concentrations of CO_2, CH_4, and N_2O were 390, 1.8, and 0.3 ppmv, respectively, which are higher than pre-industrial levels by about 40, 150, and 20 percent, respectively.

> The globally averaged combined land and ocean surface temperature data, as calculated by a linear trend, showed an average warming of 1.5°F (0.85°C) over the period 1880 to 2012. The average total increase between the 1850 to 1900 period and the 2003 to 2012 period was 1.4°F (0.78°C).

> Ocean warming dominates the increase in energy stored in the climate system, accounting for more than 90 percent of the energy accumulated between 1971 and 2010. The rate of sea-level rise since the mid-19th century has been larger than the mean rate during the previous 2 millennia. Over the period 1901 to 2010, global mean sea level rose by 0.62 foot (0.19 meter).

Over the last 2 decades, the Greenland and Antarctic ice sheets have been losing mass, glaciers have continued to shrink almost worldwide, and Arctic sea ice and Northern Hemisphere spring snow cover have continued to decrease in extent.

The mobile sources used in mosquito and vector control activities emit GHGs and, therefore, contribute incrementally to climate change; however, as described in Section 11.2.2, these emissions comprise a very small fraction of the Bay Area, California, and national GHG inventories. This fact precludes any meaningful analysis of quantitative effects that mosquito and vector control operations may specifically have on climate, although taken together with regional, national, and worldwide GHG emissions, global effects are as described above.

11.1.3 Greenhouse Gases and Their Emissions

11.1.3.1 The Atmosphere

Air is a mixture of constituent gases and its composition varies slightly with location and altitude. For 20th century scientific and engineering purposes, it became necessary to define a standard composition known as the US Standard Atmosphere. In addition to the common gases (nitrogen, oxygen, CO_2, CH_4, hydrogen, N_2O), the atmosphere contains noble or inert gases (argon, neon, helium, krypton, xenon). Radon is also present in low concentrations near ground level in limited geographic areas where it is naturally emitted from certain types of rock and soil. Table 11-1 shows the typical composition of dry standard air, which is over 99 percent nitrogen and oxygen (UIG 2008; USEPA 2012c). The apparent molecular weight of dry standard air is 28.966 grams per mole (Jennings 1970; du Pont 1971).

Table 11-1 Standard Composition of Dry Air

Principal Gas	Chemical Symbol	Gas MW g/mole	Concentration ppmv	Fraction Percent	Fraction MW g/mole
Nitrogen	N_2	28.014	780,805.00	78.080500	21.873471
Oxygen	O_2	31.998	209,440.00	20.944000	6.701661
Argon	Ar	39.948	9,340.00	0.934000	0.373114
Carbon Dioxide	CO_2	44.009	387.69	0.038769	0.017062
Neon	Ne	20.183	18.21	0.001821	0.000368
Helium	He	4.003	5.24	0.000524	0.000021
Methane	CH_4	16.043	1.81	0.000181	0.000029
Krypton	Kr	83.800	1.14	0.000114	0.000096
Hydrogen	H_2	2.016	0.50	0.000050	0.000001
Nitrous Oxide	N_2O	44.013	0.32	0.000032	0.000014
Xenon	Xe	31.300	0.09	0.000009	0.000003
Totals			**1,000,000.00**	**100.000**	**28.966**

Sources: UIG 2008; USEPA 2012c; du Pont 1971; Jennings 1970

Notes:

MW = molecular weight, g/mole

ppmv = parts per million by volume (10^{-6})

The atmosphere consists of five basic altitude zones: troposphere (sea level to 8 miles), stratosphere (8 to 32 miles), mesosphere (32 to 50 miles), thermosphere (50 to 350 miles), and exosphere (350 to 500 miles). Within the stratosphere is the ozone layer (9 to 22 miles), which absorbs ultraviolet wavelengths; and within the mesosphere is the ionosphere (62 to 190 miles), which reflects shortwave radio signals and produces auroras. These approximate altitude ranges vary with latitude, season, solar activity, and turbulence. GHGs persist mainly in the troposphere and stratosphere – some in the mesosphere – for different lengths of time, ranging from less than 5 years to over 50,000 years, long enough to become well-mixed, meaning that atmospheric concentrations are about the same all over the world, regardless of source locations (USEPA 2012d). Thus, the homogeneous composition of the lower atmosphere is the global setting for climate change.

11.1.3.2 Greenhouse Gases

Gases that trap heat in the atmosphere are called GHGs. Principal GHGs include CO_2, CH_4, N_2O, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride (SF_6), and other fluorinated gases including nitrogen trifluoride and hydrofluorinated ethers. GHGs occur naturally because of volcanoes, forest fires, and biological processes such as enteric fermentation and aerobic decomposition. They are also produced by combustion of fuels, industrial processes, agricultural operations, waste management, and land use changes such as loss of farmland to urbanization. The most common GHG from human activity (fuel combustion) is CO_2, followed by CH_4 and N_2O. (USEPA 2012d)

Concentration, or abundance, is the amount of a particular gas in the air. Larger GHG emissions lead to higher concentrations in the atmosphere. GHG concentrations are measured in units of parts per million (ppm), parts per billion (ppb), and parts per trillion (ppt). One ppm is equivalent to 1 cubic centimeter (cc) of pure gas diluted in 1 cubic meter of air. Similarly, 1 ppb is 1 cc diluted in 1,000 cubic meters, and 1 ppt is 1 cc diluted in 1,000,000 cubic meters. (USEPA 2012d)

11.1.3.2.1 Carbon Dioxide

CO_2 enters the atmosphere through burning fossil fuels (coal, natural gas, and petroleum products), decomposition of solid waste, trees and wood products, fermentation, and also as a result of certain chemical reactions, such as manufacture of cement. CO_2 is removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biologic carbon cycle. In the carbon cycle, carbon in various molecular forms is cycled among atmospheric, oceanic, land biotic, marine biotic, and mineral reservoirs. Atmospheric CO_2 is part of this global carbon cycle. CO_2 concentrations in the atmosphere have increased from about 280 ppm in preindustrial times to about 390 ppm today, a 39 percent increase. The IPCC notes that “this concentration has not been exceeded during the past 420,000 years, and likely not during the past 20 million years. The rate of increase over the past century is unprecedented, at least during the past 20,000 years.” The IPCC definitively states that “the present atmospheric CO_2 increase is caused by anthropogenic emissions of CO_2.” (USEPA 2012d; IPCC 2007)

Global Warming Potential (GWP) is a quantified measure of the globally averaged relative radiative forcing impacts of a particular GHG. It is defined as the cumulative radiative forcing both direct and indirect effects integrated over a period of time from the emission of a unit mass of gas relative to a reference gas. CO_2 is the reference gas with a GWP of unity (1). Carbon dioxide equivalents (CO_2e) are calculated by summing the products of mass GHG emissions by species times their respective USEPA official GWP coefficients. The persistence of CO_2 in the atmosphere is estimated to be in the range of 50 to 200 years, depending on variations in the carbon cycle. (USEPA 2012c, 2012d, 2014b)

11.1.3.2.2 Methane

CH_4 is primarily produced through anaerobic decomposition of organic matter in biological systems. Agricultural processes such as wetland rice cultivation, enteric fermentation in ruminant animals (e.g., cows), and the decomposition of animal wastes emit CH_4, as does the decomposition of municipal solid wastes. CH_4 is also fugitively emitted during the production and distribution of natural gas and petroleum, and is released as a by-product of coal mining and incomplete fossil fuel combustion. Pipeline-quality natural gas is over 90 percent CH_4 by volume and is considered a "clean fuel" by industry with CO_2 and water vapor as its main combustion by-products. Atmospheric concentrations of CH_4 have increased by about 160 percent since preindustrial times, although the rate of increase has been declining. The IPCC has estimated that slightly more than half of the current CH_4 flux to the atmosphere is anthropogenic, from human activities such as agriculture, fossil fuel use, and waste disposal. The USEPA's official GWP coefficient of CH_4 is 21, and its persistence in the atmosphere is estimated to be about 9 to 15 years. (USEPA 2012c, 2012d, 2014b)

11.1.3.2.3 Nitrous Oxide

N_2O is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste. Anthropogenic sources of N_2O emissions include agricultural soils, especially the use of synthetic and manure fertilizers; fossil fuel combustion, especially from mobile combustion; adipic (nylon) and nitric acid production; wastewater treatment and waste combustion; and biomass burning. The atmospheric concentration of N_2O has increased by about 19 percent since 1750, from a preindustrial value of about 270 to about 320 ppb today, a concentration that has not been exceeded during the last thousand years. The USEPA's official GWP coefficient of N_2O is 310, and its persistence in the atmosphere is estimated to be about 110 to 120 years. (USEPA 2012c, 2012d, 2014b)

11.1.3.2.4 Fluorinated Gases

Hydrofluorocarbons, perfluorocarbons, and SF_6 are synthetic, powerful GHGs that are emitted from a variety of industrial processes. Fluorinated gases are sometimes used as substitutes for ozone-depleting substances (e.g., chlorofluorocarbons, hydrochlorofluorocarbons, and halons). In the electric utility industry, SF_6 is used as a dielectric gas in high-voltage equipment, such as switchgear and circuit breakers. As man-made gas, SF_6 in the atmosphere has increased from 0 to about 7 ppt in modern times. Due to their expense, all of these fluorinated gases are typically emitted (lost) in small quantities relative to combustion by-products, but because they are potent GHGs, they are sometimes referred to as "High GWP gases" with estimated persistence in the atmosphere ranging from 1.5 to 50,000 years. Of these, SF_6 is the most potent, with an USEPA official GWP of 23,900 and an estimated persistence of about 3,200 years. (USEPA 2012c, 2012d, 2014b)

11.1.3.3 Emission Sources

The USEPA tracks GHG emissions in the US and publishes the *Inventory of U.S. Greenhouse Gas Emissions and Sinks*, which is updated annually (USEPA 2012c, 2014b). This detailed report contains estimates of the total national GHG emissions and removals associated with human activities in all 50 states. From the current report, the main sources of GHG emissions in the US are identified below (USEPA 2012d):

> Electric power generation

> Transportation

> Industry

> Commercial and residential

> Agriculture

Land Use and Forestry offsets (absorbs or sequesters) about 15 percent of GHG emissions nationwide. Land areas can act as GHG sinks (absorbing CO_2 from the atmosphere) or GHG sources. Since 1990, well-managed forests and other lands have absorbed more CO_2 from the atmosphere than they emit.

11.1.3.4 Mobile Sources

While stationary sources such as power plants and oil refineries emit large quantities of GHGs, mobile sources, due to their sheer numbers nationwide, also emit significant amounts. Mobile sources include onroad vehicles (e.g., automobiles, trucks, motorcycles), offroad equipment (e.g., earthmovers, cranes, portable pumps, and generators), trains (e.g., freight, passenger, light rail), vessels (e.g., boats, ships, watercraft), and aircraft (e.g., general aviation, commercial, military). Mobile source fuels include gasoline, diesel, heavy fuel oil (large marine vessels), and jet fuel, all of which emit GHGs when combusted.

Mobile sources used in mosquito and/or vector control activities include onroad fleet vehicles (light- and medium-duty trucks, vans, passenger cars), offroad ATVs, watercraft (motorboats, airboats), aircraft (helicopters and fixed-wing), portable equipment (pumps, sprayers, generators), and small equipment (handheld sprayers, foggers, dusters). Except for 2-stroke engines used in small lightweight equipment (spark ignition, 50:1 gas/oil mix), engines are 4-stroke gasoline (spark ignition) or diesel fuel (compression ignition). The dominant fuel used for these mobile sources is motor gasoline along with some diesel fuel (larger trucks), aviation gasoline (fixed-wing aircraft), and jet fuel (turbine-powered helicopters). Light trucks, vans, and passenger cars are normally used for responding to public service requests and disease pathogen surveillance. Typical GHG contents of common fuels are presented in Table 11-2.

Table 11-2 Typical GHG Contents of Common Fuels

Fuel	CO_2 kg/mmBTU	CH_4 kg/mmBTU	N_2O kg/mmBTU	CO_2e lb/mmBTU	Energy BTU/gal	CO_2e lb/gal
Diesel Fuel No. 2	73.96	0.0105	0.0006	163.97	138,300	22.68
Kerosene	73.19	0.0105	0.0006	162.27	138,700	22.51
Jet Fuel	72.23	0.0105	0.0006	160.17	135,000	21.62
Motor Gasoline	71.35	0.0105	0.0006	158.23	122,600	19.40
Aviation Gasoline	69.15	0.0105	0.0006	153.38	120,200	18.44
Propane	62.22	0.0053	0.0001	137.49	91,300	12.55
Pipeline Natural Gas	53.02	0.0053	0.0001	117.20	—	—

Sources: USEPA 2012c, 2011a

Notes:

BTU = the amount of energy (heat) required to raise 1 pound of liquid water 1 degree Fahrenheit from 39 to 40°F

kg/mmBTU = kilogram(s) per million British Thermal Units

lb/mmBTU = pound(s) per million British Thermal Units

11.1.3.5 Sensitive Receptors

Certain population groups are considered more sensitive to air pollution and odors than others; in particular, children, elderly, and acutely ill and chronically ill persons, especially those with cardiorespiratory diseases such as asthma and bronchitis. Sensitive receptors (land uses) indicate locations where such individuals are typically found, namely schools, daycare centers, hospitals, convalescent homes, residences of sensitive persons, and parks with active recreational uses, such as youth sports.

None of the GHGs described in Section 11.2.2 are considered toxic; however, all are classified as asphyxiants. Thus, in high enough concentrations in confined spaces they can displace the oxygen in air

and present hazards to industrial workers; however, GHG concentrations in ambient air (see Table 11-1) are far below any danger levels. Therefore, no risk to sensitive receptors or the general public is posed by GHGs emitted to outdoor air, either from stationary or mobile sources.

11.1.4 California Climate Impacts

Climate change is already affecting California. Average temperatures have increased, leading to more extreme hot days and fewer cold nights. Shifts in the water cycle have been observed, with less winter precipitation falling as snow, and both snowmelt and rainwater running off earlier in the year. Sea levels have risen. Wildland fires are becoming more frequent and intense due to dry seasons that start earlier and end later. These climate-driven changes affect resources critical to the health and prosperity of California. (CEC 2010)

If the state takes no action to reduce or minimize expected impacts from future climate change, the costs could be severe. In November 2008, the Governor directed the California Natural Resources Agency to develop a climate adaptation strategy for California. The Natural Resources Agency coordinated with ten state agencies, multiple scientists, a consulting team, and stakeholders to develop the first statewide, multisector adaptation strategy in the country. The resulting report, *2009 California Climate Adaptation Strategy*, summarizes the best-known science to assess the vulnerability of the state to climate change impacts, and outlines possible solutions that can be implemented within and across state agencies to promote resiliency. This strategy is the first step in an evolving process to reduce California's vulnerability to climate change impacts. (CEC 2010)

The Global Warming Solutions Act of 2006 (Assembly Bill [AB] 32) (see Appendix C) required CARB to prepare a Scoping Plan to achieve substantial GHG emissions reductions, both from within the state and from "exported" emissions, such as importing electric power generated at coal-fired power plants located in neighboring western states. The 2008 Scoping Plan outlines a wide range of strategies for reducing statewide GHG emissions to 1990 levels by 2020. This goal will be achieved by cutting about 30 percent from business-as-usual emission levels projected for 2020, or about 15 percent from 2008 levels. Allowing for population growth, the goal is to reduce annual per capita emissions from 14 metric tonnes (MT) CO_2e down to about 10 MT CO_2e per capita by 2020. (CARB 2008b)

11.1.5 Emissions Inventories

The bulk of mosquito and vector control activity emissions would occur in the Bay Area portion of the District's Service Area (i.e., Marin and Sonoma counties), and only minor amounts would occur in Yolo, Solano, Lake, and Mendocino counties within the Program Area. Therefore, the comprehensive 2007 Bay Area GHG inventory is used as the regional benchmark for comparison purposes.

Table 11-3 shows aggregated national, state, and regional GHG emissions for all sources on a gross basis (i.e., CO_2e emissions only, not including CO_2 sinks such as forestry and agriculture) bracketing the 2007 BAAQMD GHG inventory by 2 years, i.e., from 2005 through 2009. As shown, California accounts for about 7 percent of gross CO_2e emissions in the US annually, and the Bay Area accounts for about 20 percent of gross CO_2e emissions in California.

Table 11-3 Greenhouse Gas Emissions Inventories - Gross Basis

Summary Year	National MMT CO_2e	California MMT CO_2e	Bay Area MMT CO_2e
2005	7,204	482.5	—
2006	7,159	481.9	—
2007	7,253	488.8	95.8
2008	7,048	484.7	—
2009	6,608	456.8	—
5-Year Average	**7,054**	**478.9**	—
Average Annual Variation	**2.6%**	**1.8%**	—

Sources: USEPA 2012c; CARB 2011; BAAQMD 2010c

Notes:

MMT - million metric tonnes (annual); 1 metric tonne = 1,000 kilograms or 2,204.6 pounds

2009 is most recent CARB published data; Bay Area for 2007 only

The bulk of the District's GHG emissions would occur in the San Francisco Bay Area. Tables 11-4, 11-5, 11-6, and 11-7 present progressively focused Bay Area GHG emissions inventory data for 2007 broken down by sectors, counties, and applicable subsectors. The District's Program Area counties within the BAAQMD are shown in bold. This information will be used as a basis for comparisons with estimated mosquito and vector control activity emissions for the District presented in Section 11.2.2.

Table 11-4 Bay Area GHG Emissions by Sector

End-Use Sector	District Emissions Percent	District Emissions MMT CO_2e
Industrial / Commercial	36.4%	34.9
Residential Fuel Use	7.1%	6.8
Local Electric Power Generation	8.5%	8.1
Imported Electric Power Generation	7.4%	7.1
Offroad Equipment	3.0%	2.9
Transportation	36.4%	34.9
Agriculture / Farming	1.2%	1.1
Totals	**100.0%**	**95.8**

Source: BAAQMD 2010c

Notes:

MMT - million metric tonnes (annual); 1 metric tonne = 1,000 kilograms or 2,204.6 pounds

Table 11-5 Bay Area GHG Emissions by County

County	District Emissions Percent	District Emissions MMT CO_2e
Alameda	16.4%	15.7
Contra Costa	32.9%	31.5
Marin	**2.8%**	**2.7**
Napa	1.8%	1.7
San Francisco	7.4%	7.1
San Mateo	8.9%	8.5
Santa Clara	19.6%	18.8
Solano (within BAAQMD)	**5.9%**	**5.7**
Sonoma (within BAAQMD)	**4.3%**	**4.1**
Totals	**100.0%**	**95.8**

Source: BAAQMD 2010c

Notes:

MMT - million metric tonnes (annual); 1 metric tonne = 1,000 kilograms or 2,204.6 pounds

Table 11-6 Mobile Sectors GHG Emissions by County

County	Offroad MT CO_2e	Transportation MT CO_2e
Alameda	569,000	8,351,000
Contra Costa	406,000	4,998,000
Marin	**99,000**	**1,286,000**
Napa	50,000	917,000
San Francisco	415,000	2,673,000
San Mateo	270,000	4,850,000
Santa Clara	790,000	7,859,000
Solano (within BAAQMD)	**147,000**	**1,834,000**
Sonoma (within BAAQMD)	**175,000**	**2,103,000**
Totals	**2,921,000**	**34,871,000**

Source: BAAQMD 2010c

Notes:

MMT - million metric tonnes (annual); 1 metric tonne = 1,000 kilograms or 2,204.6 pounds

Values rounded to nearest 1,000 tonnes

"Offroad" is offroad equipment category

Table 11-7 Offroad Subsectors GHG Emissions by County

County	Utility MT CO_2e	Commercial MT CO_2e	Combined MT CO_2e
Alameda	29,800	49,900	79,700
Contra Costa	20,300	26,900	47,200
Marin	7,900	12,300	20,200
Napa	2,900	4,300	7,200
San Francisco	14,200	43,900	58,100
San Mateo	14,200	27,200	41,400
Santa Clara	32,900	56,500	89,400
Solano (within BAAQMD)	**3,900**	**6,800**	**10,700**
Sonoma (within BAAQMD)	**7,800**	**13,500**	**21,300**
Totals	**133,900**	**241,300**	**375,200**

Source: BAAQMD 2010c

Notes:

MMT - million metric tonnes (annual); 1 metric tonne = 1,000 kilograms or 2,204.6 pounds

Values rounded to nearest 100 tonnes

"Utility" is small landscaping equipment selected for comparisons to Districts' activities

"Commercial" is light commercial equipment selected for comparisons to Districts' activities

11.1.6 Potential for Mitigation

With respect to mosquito and vector control activities, BMPs include fuel conservation, which minimizes GHG emissions by the Program, as described in Section 11.2.11.

11.1.7 Regulatory Setting

Currently, no local, state, or federal regulatory standards directly apply to GHG emissions from temporary or intermittent mobile sources such as mosquito and vector control activities. However, in the context of the Scoping Plan discussed in Section 11.1.4.1, implementation of Low Carbon Fuel Standard (Executive Order S-1-7, below) would indirectly apply to mosquito and vector control activities via fuel usage. Principal federal, state, and local GHG statutes, regulations, and programs that affect other types of sources are presented in Appendix C with the CEQA Guidelines summarized below in Section 11.1.7.3.

11.1.7.1 Federal

11.1.7.1.1 40 CFR Part 98 – Greenhouse Gas Reporting

On October 30, 2009, the USEPA issued the Mandatory Reporting of Greenhouse Gases rule (74 FR 56260, 40 CFR 98, effective December 29, 2009), which requires reporting of GHG data and other relevant information from large sources and suppliers in the United States pursuant to Fiscal Year 2008 Consolidated Appropriations Act (HR 2764; Public Law 110-161).

The new rule facilitates collection of accurate and comprehensive emissions data to provide a basis for future USEPA policy decisions and regulatory initiatives. The rule requires specified industrial source categories and facilities with an aggregated heat input of 30 mmBTU or more per hour or that emit 25,000 metric tons or more per year of GHG to submit annual reports to the USEPA. The gases covered by the rule are CO_2, CH_4, N_2O, and hydrofluorocarbons, perfluorocarbons, SF_6, and other fluorinated gases

including nitrogen trifluoride and hydrofluorinated ethers. Since the Program does not meet the definition of an affected stationary source (i.e., mobile sources only), the GHG reporting rule does not apply.

Notwithstanding the GHG reporting rule, no federal regulations currently limit or curtail GHG emissions of CO_2 and CH_4, and USEPA cap-and-trade programs currently apply only to acid rain precursors SO_2 and NO_X (USEPA 2012e). However, N_2O emissions are regulated, albeit indirectly, through limitation of NO_X emissions as a criteria pollutant under New Source Performance Standards (NSPS) and federal, state, and local operating permits.

11.1.7.1.2 General Conformity

A General Conformity determination is required for federally sponsored, permitted, or funded actions in NAAQS nonattainment areas or in certain maintenance areas when the total direct and indirect net emissions of nonattainment pollutants (or their precursors) exceed specified thresholds (CAA Amendments of 1990 Section 176[c]). This regulation ensures that federal actions conform to SIPs and agency NAAQS attainment plans. Since GHGs are not regulated criteria air pollutants and the Program is not federally sponsored, permitted, or funded actions, General Conformity does not apply.

11.1.7.2 State

11.1.7.2.1 Global Warming Solutions Act

The Global Warming Solutions Act of 2006 (AB 32) codifies California's goal of reducing statewide GHG emissions to 1990 levels by 2020. This reduction will be accomplished through an enforceable statewide cap on global warming emissions that was phased in starting in 2012 to achieve maximum technologically feasible and cost-effective GHG emission reductions. To effectively implement the cap, AB 32 directs CARB to develop appropriate regulations and establish a mandatory reporting system to track and monitor global warming emissions levels.

On September 25, 2009, CARB adopted the AB 32 Cost of Implementation Fee Regulation (Health and Safety Code 38597). The regulation was approved by the Office of Administrative Law on June 17, 2010, and became effective on July 19, 2010. For the first year of the fee program, CARB administratively provided compliance flexibility and did not enforce reporting and fee requirements until after the passage of the state budget for fiscal year 2010-11. Until CARB provides detailed compliance criteria, facilities subject to the regulation do not need to pay fees or report information required by the regulation. However, since the Program is not affected by stationary sources, the AB 32 fee regulation does not apply.

11.1.7.2.2 Cap and Trade

CARB's new "Cap and Trade" regulation (Subchapter 10, Article 5, Sections 95800 to 96023, Title 17, CCR) is a set of rules (effective September 1, 2012) that establishes a limit on GHG emissions from the largest sources of GHGs in the state. The purpose of *California Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanisms* is to reduce GHG emissions from affected stationary sources through the establishment, administration, and enforcement of an aggregate GHG allowance budget and to provide a trading mechanism for compliance instruments (i.e., "GHG allowances" or "carbon credits"). Since the Program is not affected by stationary sources under the rule, Cap and Trade does not apply. No other statewide quantitative standards of significance for GHG impacts have been established for nonaffected sources under CEQA.

11.1.7.2.3 Assembly Bill 939

California AB 939, known as the Integrated Waste Management Act of 1989, was enacted due to increasing waste stream volumes and decreasing landfill capacities in the state. As a result of AB 939, the California Integrated Waste Management Board was created. A disposal reporting system with its oversight was established, and facility and program planning was required. AB 939 mandated that

sanitation districts (jurisdictions) meet diversion goals of 25 percent by 1995 and 50 percent by 2000, primarily through recyclables collection and green waste compositing. AB 939 also established an integrated framework for program implementation, solid waste planning, and solid waste facility and landfill compliance.

11.1.7.2.4 Senate Bill 1368

California Senate Bill (SB) 1368 adds Sections 8340 and 8341 to the Public Utilities Code (effective January 1, 2007) with the intent "to prevent long-term investments in power plants with GHG emissions in excess of those produced by a combined-cycle natural gas power plant" with the aim of "reducing emissions of GHGs from the state's electricity consumption, not just the state's electricity production." SB 1368 provides a mechanism for reducing the GHG emissions of electricity providers, both in state and out of state, thereby assisting CARB in meeting its mandate under AB 32, the Global Warming Solutions Act of 2006.

11.1.7.2.5 Senate Bill 97

California SB 97 directs the Office of Planning and Research to prepare, develop, and transmit to the Resources Agency CEQA guidelines for the feasible mitigation of GHG emissions or their effects by July 1, 2009. The Resources Agency was required to certify or adopt those guidelines by January 1, 2010. SB 97 also protects, for a short time, certain projects funded by the Highway Safety, Traffic Reduction, Air Quality and Port Security Bond Act of 2006, or the Disaster Preparedness and Flood Protection Bond Act of 2006 (Proposition 1B or 1E) from claims of inadequate analysis of GHGs as a legitimate cause of action. This latter provision was repealed on January 1, 2010.

11.1.7.2.6 Senate Bill 375

California SB 375 aims to reduce GHG emissions by curbing sprawl, because the largest sources of GHG emissions in California are passenger vehicles and light trucks. SB 375 provides emission reduction goals for which regions can plan, integrates disjointed planning activities, and provides incentives for local governments and developers to follow new conscientiously planned growth patterns. SB 375 enhances CARB's ability to reach AB 32 goals by requiring metropolitan planning organizations to include defined sustainable community strategies in their regional transportation plans for the purpose of reducing GHG emissions, aligns planning for transportation and housing, and creates specified incentives for the implementation of the strategies.

11.1.7.2.7 Senate Bills 1078 and 10

California SB 1078 was signed into legislation in 2002 and required California load-serving entities (electric utilities) to procure 20 percent of their retail customer load with renewable energy by the year 2017. Four years later (2006), SB 10 accelerated the 20 percent renewable deadline to 2010.

11.1.7.2.8 Executive Order S-20-04

On July 27, 2004, Executive Order S-20-04 was issued committing the state to aggressive action to reduce state-owned building electricity usage by retrofitting, building, and operating the most energy and resource efficient buildings by taking all cost-effective measures described in the Green Building Action Plan with the goal of reducing grid-based energy purchases by 20 percent by 2015. This order also directed the California Public Utilities Commission to support a campaign to improve commercial building energy efficiency to help achieve the 20 percent goal and to develop a benchmarking methodology.

11.1.7.2.9 Executive Order S-3-05

On June 1, 2005, Executive Order S-3-05 was issued establishing GHG emission reduction targets: by 2010, reduce GHG emissions to 2000 levels; by 2020, reduce GHG emissions to 1990 levels; and by 2050, reduce GHG emissions to 80 percent below 1990 levels.

11.1.7.2.10 Executive Order S-1-07

On January 18, 2007, the Low Carbon Fuel Standard (LCFS) was issued mandating a reduction of at least 10 percent in the carbon intensity of California's transportation fuels by 2020. It instructed the California Environmental Protection Agency to coordinate activities among the University of California, the California Energy Commission (CEC), and other state agencies to develop and propose a draft compliance schedule to meet the 2020 target. Furthermore, it directed CARB to consider initiating regulatory proceedings to establish and implement the LCFS. In response, CARB identified the LCFS as an early action item with a regulation to be adopted and implemented by 2010.

11.1.7.2.11 Executive Order S-13-08

On November 14, 2008, Executive Order S-20-04 was issued directing the California Resources Agency, in cooperation with the California Department of Water Resources, the CEC, California's coastal management agencies, and the Ocean Protection Council to request that the National Academy of Sciences convene an independent panel to complete the first California Sea Level Rise Assessment Report by December 1, 2010. As part of this effort, the Resources Agency is to create an independent sea-level rise science and policy committee made up of state, national, and international experts and to hold public workshops to gather policy-relevant information.

11.1.7.3 Local

11.1.7.3.1 BAAQMD CEQA Guidelines

On June 2, 2010, the BAAQMD Board adopted a significant update to its December 1999 *CEQA Air Quality Guidelines*. BAAQMD issued clarifications and minor edits to the June 2010 guidelines. *CEQA Air Quality Guidelines* is a guidance document to provide lead government agencies, consultants, and project proponents with uniform procedures for assessing air quality impacts and preparing the air quality sections of environmental documents for projects subject to CEQA. The document describes the criteria that BAAQMD uses when reviewing and commenting on the adequacy of environmental documents. It recommends quantitative thresholds for use in determining whether construction and operational activities associated with projects would have significant adverse environmental impacts, identifies methodologies for predicting project emissions and impacts, and identifies measures that can be used to avoid or reduce air quality and GHG impacts. (BAAQMD 2011, 2012)

However, due to a legal challenge,[1] the adopted 2011 Guidelines and significance thresholds (BAAQMD 2011) are no longer officially in effect. Per the revised and adopted 2012 Guidelines (BAAQMD 2012), lead agencies have the discretion to use either the adopted 1999 thresholds or the more stringent 2010/2011 thresholds.[2] At the District's request, the GHG analysis will follow the 2010/2011 significance thresholds because the District has determined that Appendix D of the guidelines, in combination with the

[1] On March 5, 2012, the Alameda County Superior Court issued a judgment finding that BAAQMD had failed to comply with CEQA when it adopted the Thresholds. The court did not determine whether the Thresholds were valid on the merits, but found that the adoption of the Thresholds was a project under CEQA. The court issued a writ of mandate ordering BAAQMD to set aside the Thresholds and cease dissemination of them until BAAQMD had complied with CEQA. BAAQMD has appealed the Alameda County Superior Court's decision. The Court of Appeal of the State of California, First Appellate District, reversed the trial court's decision. The Court of Appeal's decision was appealed to the California Supreme Court, which granted limited review, and the matter is currently pending there.

[2] Due to the March 5, 2012, writ of mandate, which set aside BAAQMD's adopted 2010 CEQA Thresholds of Significance, BAAQMD cannot recommend specific thresholds of significance for use by local governments at this time (October 2014). Lead agencies will need to determine appropriate air quality thresholds to use for each project they review based on substantial evidence that they should include in the administrative record for the project. Lead agencies should examine the substantial evidence in determining appropriate air quality thresholds. Lead agencies may reference BAAQMD's 1999 Thresholds of Significance. Lead agencies may also reference BAAQMD's CEQA Thresholds Options and Justification Report developed by staff in 2009. The CEQA Thresholds Options and Justification Report outlines substantial evidence supporting a variety of thresholds of significance. In accordance with the court order referenced above, BAAQMD cannot and does not endorse or recommend any of the particular thresholds outlined therein.

BAAQMD Revised Draft Options and Justification Report (BAAQMD 2009), provides substantial evidence to support the 2010/2011 significance thresholds and, therefore, has determined they are appropriate for use in this analysis in lieu of the 1999 significance thresholds.

The 2010/2011 *CEQA Air Quality Guidelines* do not comprise enforceable rules or regulations per se; nevertheless, the guidelines established the following quantitative thresholds of significance for GHG emissions[3] (see Table 10-3):

> Stationary Sources: 10,000 MT CO_2e per year

> Other than Stationary Sources: 1,100 MT CO_2e per year or 4.6 MT CO_2e per SP per year

> Plans: 6.6 MT CO_2e per SP per year

Under the 2010/2011 *CEQA Air Quality Guidelines*, Program status would presumably be as follows:

> Mosquito and vector control activities do not meet the regulatory definition of a stationary source of air contaminants; therefore, the 10,000 MT CO_2e per year stationary source GHG threshold would not apply.

> For nonstationary source land use development projects, BAAQMD's adopted "bright-line" threshold of significance differs from other proposed GHG thresholds currently under consideration in California. Under this threshold, to conclude that a project's GHG impacts are less than significant, a project would need to be in compliance with a "Qualified Greenhouse Gas Reduction Strategy," emit less than 1,100 MT CO_2e per year, or emit less than 4.6 MT CO_2e per year per capita SP (residents + employees). However, the District's IVMP does not qualify as a land use development project; therefore, these GHG thresholds would not apply.

> No GHG thresholds exist for temporary construction emissions from mobile and portable sources, neither daily nor annual, whether for stationary or nonstationary source projects. Since mosquito and vector control activities comprise mobile and portable sources similar to construction, no quantitative GHG significance thresholds would apply to the Program since activities such as mosquito and vector control are not specified, defined, or addressed in the guidelines.

Notwithstanding the above criteria, for evaluation purposes the estimated maximum annual Program emissions are compared to the 1,100 MT CO_2e per year significance threshold for projects that are not stationary sources, e.g., mosquito and vector control activities, as presumptive "land use" projects.

11.1.7.3.2 Other Air Districts' CEQA Guidelines

Portions of the District's Service Area are outside the BAAQMD, i.e., in northern Sonoma County, and portions of the Program Area (eastern Solano County, Yolo County, Mendocino County, and Lake County) are in the jurisdiction of other air districts. Neither NSCAPCD, YSAQMD, MCAQMD, nor LCAQMD have applicable CEQA thresholds for GHGs, as discussed below.

Since the southern portion of Sonoma County is within the BAAQMD, NSCAPCD (2014) generally follows BAAQMD guidelines as appropriate for countywide consistency.

The YSAQMD *Handbook for Assessing and Mitigating Air Quality Impacts* (2007) contains Appendix A3.3, Characteristics and Health Effects of Air Pollutants, in which GHGs are briefly discussed. With respect to CEQA, the YSAQMD acknowledges that "the issue of climate change has become increasingly connected to the CEQA process in recent years". Further, the YSAQMD "recommends that impacts to climate change be evaluated for every CEQA project" and cites a "number of helpful resources exist to assist with this evaluation" including the California Air Pollution Control Officers Association (CAPCOA) document *CEQA & Climate Change* (2008). However, the CAPCOA document contains no

[3] MT = metric tonne, 1,000 kilograms or 2,204.6 pounds; SP = Service Population, residents + employees

quantitative criteria for evaluating projects that are not stationary sources or land use developments. Thus, YSAQMD presently has no quantitative GHG thresholds applicable to the Program and the BAAQMD thresholds presumptively apply. (YSAQMD 2013)

On June 2, 2010, the MCAQMD Board adopted GHG thresholds of significance equivalent to the 2010/2011 BAAQMD thresholds described above and shown in Table 10-3 (Plans excluded) (MCAQMD 2010).

LCAQMD (2014) provides a number of "Climate Change Website Links" related to CEQA, but has no specific guidelines or thresholds related to GHGs and the BAAQMD thresholds presumptively apply.

11.1.7.3.3 Marin County and Cities Climate Change Related Policies

Notwithstanding air district CEQA guidelines on GHGs and climate change, many counties and cities in California have developed climate change policies and action plans that are primarily used as planning and operations management tools. As planning tools, the general aim is to implement "smart growth" policies, prevent unmitigated sprawl, conserve energy and water, and reduce automobile dependence – all of which reduce climate impacts either directly or indirectly. As operations management tools, the general aim is to minimize direct and indirect GHG emissions from government operations, mainly through energy conservation.

Marin County

CEQA Guidelines

In Marin County, the CEQA Guidelines must be used in conjunction with the Environmental Impact Review Guidelines (MCCDA 1994) to determine the local policies and procedures to be followed in implementing CEQA. As such, CEQA Guidelines Appendix G, *Environmental Checklist Form*, Section VII (Greenhouse Gases) applies. Further, the updated Countywide Plan (MCCDA 2007a) acknowledges Section VII by advocating "[a] reduced ecological footprint. Marin residents and businesses shall increasingly use renewable energy, fuel-efficient transportation choices, and green building and businesses practices similar to the level of Western Europe." (MCCDA 2007b)

Climate Action Plan

In its *Climate Action Plan 2014 Update* (MCCDA 2014), Marin County acknowledges the consensus among leading scientists that without action to reduce GHG emissions, climate change due to global warming will pose a considerable threat to the environment and to human health and society.

Marin County was one of the first counties in California to take formal action addressing GHG emissions when it adopted the Marin County GHG Reduction Plan in 2006. Measures identified in the GHG Reduction Plan were then incorporated into the Marin Countywide Plan update, which was adopted in 2007. Consistent with AB 32, the 2006 GHG Reduction Plan set a target to reduce GHG emissions from both community and municipal activities in the unincorporated areas of Marin County by at least 15 percent below 1990 levels by 2020. The County government and private sector have invested heavily in energy efficiency, renewable energy, alternative fuel vehicles, water conservation, and waste minimization to reduce GHG emissions substantially. By 2012, the County had already reduced community emissions to 15 percent below 1990 levels – 8 years ahead of the 2020 target. (MCCDA 2014)

The 2014 Update builds on the 2006 GHG Reduction Plan and includes two targets: (1) the 2020 Community Emissions Reduction Target – a goal to reduce GHG emissions from community activities in the unincorporated areas of Marin County by at least 30 percent below 1990 levels by 2020; and (2) the 2020 Municipal Emissions Reduction Target – a goal to reduce GHG emissions from the County's municipal activities by at least 15 percent below 1990 levels by 2020. (MCCDA 2014)

Countywide Plan (General Plan)

The updated Marin Countywide Plan was adopted November 6, 2007. The updated Plan promotes leading edge strategies started in 1974 when Marin County set in place policies that prevented runaway development and protected open space. By focusing on sustainability, the updated Plan also serves as a model for other communities to address the impending climate change crisis – including assessing GHG emissions, setting targets to reduce emissions, and programs to plan for and adapt to projected sea-level rise.

The Plan acknowledges that much of the County's built environment is powered by fossil fuels, which emit GHGs that contribute to climate change. The Plan recognizes that the County must retrofit existing buildings and increase the use of fuel-efficient transportation to realize a significant energy reduction. The Plan calls for environmentally friendly building techniques and energy efficiency standards in excess of state requirements. Other innovations include the goal of reducing the County's ecological footprint to Western European levels, and using benchmarks to track progress in implementing the Plan. (MCCDA 2007a)

City of Belvedere

The City of Belvedere's partnering in the *Marin County Climate Action Plan Update* (MCCDA 2014) supports its overall policy of reducing GHG emissions in concert with applicable city plans, goals, objectives, policies, and programs related to climate change. The Sustainability (SUST) and Resource Conservation Element of the General Plan contains seven sustainability-related goals that aim to reduce direct and indirect GHG emissions (BPBS 2010). To the full extent of its jurisdictional authority, the City will:

> Incorporate highest standards of green building in City facilities and encourage private property owners to incorporate high standards of energy efficiency and green building.

> Ensure that future City investments utilize energy and water conserving, efficient, and environmentally friendly technologies as much as possible.

> Support renewable energy.

> Reduce GHG emissions from all activities within the City boundaries to support the State's efforts and to mitigate the impact of climate change and sea level rise.

> Reduce solid waste disposal and increase recycling in line with Marin County's goal of 80 percent waste diversion by 2012 and zero waste generation by 2025.

> Encourage and facilitate water conservation in public and private use.

> Reduce automobile emissions; increase transit (ferry and bus) ridership, and improve bicycle and pedestrian circulation; and support the use of alternative fuel and nonmotorized vehicles.

Town of Corte Madera

The Town of Corte Madera's partnering in the *Marin County Climate Action Plan Update* (MCCDA 2014) supports its overall policy of reducing GHG emissions in concert with applicable city plans, goals, objectives, policies, and programs related to climate change. The Resource Conservation and Sustainability (RCS) Element of the General Plan (CMPD 2009) contains three Goals that aim to reduce direct and indirect GHG emissions: RCS 2 – Reduced consumption of nonrenewable energy sources in Corte Madera; RCS 3 – Reduce existing and future levels of GHG emissions originating from within the community; and RCS 10 – Attainment of air quality standards in the San Francisco Bay Air Basin. Nine RCS policies support these goals (CMPD 2009). To the full extent of its jurisdictional authority, the Town will:

> Increase energy conservation and efficiency within town buildings.

> Support the development and utilization of renewable energy.

> Minimize transportation-related energy consumption.

> Reduce energy consumption in buildings by balancing energy efficient design with good planning principles.

> Actively seek to reduce GHG emissions within the Planning Area.

> Reduce the potential for air quality [and climate change] impact of new development and redevelopment by requiring pedestrian, bicycle, and transit oriented features.

> Encourage new development and redevelopment of existing sites that will locate mixed land uses near employment and commercial service centers in order to reduce vehicular air pollution [and GHG emissions].

> Require the incorporation of air quality [and climate change] mitigation measures for development projects.

> Support the BAAQMD in monitoring air pollutants of concern, the Governor's Office of Planning and Research (OPR) in developing CEQA guidelines related to GHG emissions and energy for all projects, and in meeting federal and state air quality standards.

Town of Fairfax

The Town of Fairfax's partnering in the *Marin County Climate Action Plan Update* (MCCDA 2014) supports its overall policy of reducing GHG emissions in concert with applicable city plans, goals, objectives, policies, and programs related to climate change. The Conservation (CON) Element of the General Plan (FPD 2012) contains two main Goals that aim to reduce direct and indirect GHG emissions: Energy Conservation & Climate and Air Quality. Five Objectives support these goals: (1) Integrate reduction of the use of nonrenewable energy resources and GHG emissions into planning; (2) reduce consumption of nonrenewable energy resources and reduce GHG emissions by the residents and Town; (3) improve air quality through proper planning and building decisions; (4) improve air quality through appropriate changes to the Municipal Code; and (5) improve air quality through cooperation and coordination with regional, state, federal, and nonprofit agencies. Ten COM policies support these goals and objectives (FPD 2012). To the full extent of its jurisdictional authority, the Town will:

> Develop and implement a Climate Action Plan (CAP) for Fairfax, including within its scope both the operations of the Town government and the activities of citizens, and including both stationary and mobile sources.

> Promote zoning to facilitate live/work situations and minimize motorized transit.

> Encourage green building techniques for all new and remodel construction within the Town of Fairfax.

> Participate in statewide and countywide efforts toward energy conservation, renewable energy generation and GHG reduction.

> Implement energy efficiency and use of sustainable energy resources by Town government.

> Create an infrastructure to facilitate the use of plug-in hybrid electric vehicles (PHEVs) and electric vehicles (EVs).

> Support development approaches and usage measures near the Town Center to reduce individual motorized transportation requirements.

> All planning decisions shall require application of existing air quality guidelines and best practices to minimize air quality [and climate change] impacts.

> Improve air quality [and reduce GHGs] by encouraging green building techniques for all new and remodel construction within the Town of Fairfax.

> Support air quality [and climate change] initiatives from the State of California.

City of Larkspur

The City of Larkspur's partnering in the *Marin County Climate Action Plan Update* (MCCDA 2014) supports its overall policy of reducing GHG emissions in concert with applicable city plans, goals, objectives, policies, and programs related to climate change. A Climate Action Plan (LPD 2010) was prepared to support the 2011 General Plan update. The Health and Safety (SAF) Element of the General Plan (LPD 2011) contains two main goals that aim to reduce direct and indirect GHG emissions: SAF 9 – Protect and improve air quality and SAF10 – Reduce GHG gas emissions. Five SAF policies support these goals (LPD 2011). To the full extent of its jurisdictional authority, the City will:

> Seek to comply with state and federal ambient air quality standards.

> Seek to reduce auto travel and, thereby, the pollutants from auto emissions.

> Ensure that traffic generated by new development does not lead to nonattainment of state and federal ambient air quality standards in Marin County.

> Ensure sufficient buffers between sensitive land uses (e.g., residential, schools, and public facilities) and sources of air pollution. If sufficient buffers cannot be achieved, require adequate mitigation measures to protect sensitive receptors located near emission sources.

> Maintain a Climate Action Plan that includes a GHG inventory for municipal operations and the community at large and establishes a GHG reduction goal, in compliance with state law.

City of Mill Valley

The City of Mill Valley's partnering in the *Marin County Climate Action Plan Update* (MCCDA 2014) supports its overall policy of reducing GHG emissions in concert with applicable city plans, goals, objectives, policies, and programs related to climate change. The City is currently working on developing a Climate Action Plan with the community (MVAP 2014). The Climate Action (CL) Element of the General Plan (MVAP 2013) contains three main goals that aim to reduce direct and indirect GHG emissions: CL1 – Climate change and GHG emissions reduction; CL2 – Climate change adaptation and strategies; and CL3 – Zero waste strategies for solid waste management. Five principal CL objectives support these goals (MVAP 2013). To the full extent of its jurisdictional authority, the City will:

> Promote Clean Energy and Energy Efficiency: Support and provide incentives for using and investing in clean energy and energy efficiency solutions.

> Establish Carbon Offsets: Offset carbon emissions through carbon credits or allowances, and through natural sequestration methods.

> Conduct Monitoring: Establish a baseline and monitor the City and community contribution to GHG emissions.

> Adapt to Climate Change: Ground climate change adaptation strategies in the best-available scientific understanding of hazards, risks, impacts, and vulnerabilities, and make adaptation planning and implementation a City budgeted item and operational priority.

> Conduct Recycling and Waste Management: Reduce the volume of the waste stream by encouraging recycling and composting and moving toward Zero Waste objectives that minimize or eliminate waste sent to landfills.

City of Novato

The City of Novato's partnering in the *Marin County Climate Action Plan Update* (MCCDA 2014) supports its overall policy of reducing GHG emissions in concert with applicable city plans, goals, objectives, policies, and programs related to climate change. The Climate Change Action Plan (CCAP) Element of the General Plan Update contains ten main goals that aim to reduce direct and indirect GHG emissions (NCDD 2009). To the full extent of its jurisdictional authority, the City will:

> Reduce emissions from the energy sector through energy efficiency and conservation efforts within municipal and community operations.

> Reduce emissions associated with energy generation through promotion and support of renewable energy generation and use.

> Reduce emissions from the built environment through "green building" and urban design principles that minimize the urban heat island effect and reduce energy consumption.

> Reduce emissions associated with water conveyance and wastewater sources by increasing water conservation.

> Reduce emissions from transportation sources by promoting use of alternative fuels and efficient use of traditional automobiles.

> Reduce emissions by decreasing vehicle miles traveled (VMT) within the city through strategic land use and design.

> Reduce emissions from transportation sources through promotion of nonvehicular modes of travel.

> Reduce emissions from waste sources.

> Improve the city's resilience to reduce vulnerability to extreme events resulting from climate change.

> Implement the Climate Change Action Plan to reduce Novato's GHG emissions by a minimum of 15 percent from the 2005 baseline by 2020 and by a minimum of 40 percent by 2035.

Town of Ross

The Town of Ross' partnering in the *Marin County Climate Action Plan Update* (MCCDA 2014) supports its overall policy of reducing GHG emissions in concert with applicable city plans, goals, objectives, policies, and programs related to climate change. The Natural Environment (NE) Element of the General Plan (RPD 2007) contains Goal 2 – Sustainable Building and Community Practices, which supports measures to reduce resource consumption and improve energy efficiency, thus reducing direct and indirect GHG emissions. A Climate Action Plan (RPD 2011) has been prepared to support the next General Plan update. Nine NE policies support these goals (RPD 2007). To the full extent of its jurisdictional authority, the Town will:

> Require large houses to limit the energy usage to that of a more moderately sized house as established in design guidelines.

> Encourage affordable workforce housing and a development pattern that encourages people to walk.

> Preserve uses in the commercial area of the town that serve local residents and reduce the need to drive to other areas.

> Choose the most sustainable portion of a site for development and leaving more of a site in its natural condition to reduce land impacts on the natural environment.

> Establish “Green Building” requirements that require buildings and substantial remodels to be built using “green” building techniques, including recycling of building materials where possible, and to conform to an industry approved certification or rating such as Leadership in Energy and Environmental Design (LEED) Green Building Rating System.

> Establish irrigation standards for new landscaping to minimize water consumption.

> Promote water conservation in existing landscaping and domestic uses.

> Encourage transportation alternatives to the private automobile.

> Increase the use of renewable energy sources, including solar energy.

Town of San Anselmo

The Town of San Anselmo’s partnering in the *Marin County Climate Action Plan Update* (MCCDA 2014) supports its overall policy of reducing GHG emissions in concert with applicable city plans, goals, objectives, policies, and programs related to climate change. The Conservation (CON) Element of the General Plan (SAPD 1989) contains a Smog topic, which states that “The Air Pollution Control District [i.e., BAAQMD] has estimated that if further increases in pollutant emissions were to continue at the rate which occurred during the '50s and '60s there is a strong likelihood that air quality standards in the Ross Valley would be violated a significant number of times per year. For this reason, in addition to those specified in the Circulation Element, it is recommended that further increases in auto travel in the Ross Valley be avoided.” Due to its age (25 years), the General Plan does not address GHGs or climate change per se; however, a Climate Action Plan (SAPD 2011) has been prepared, which contains recommended policies that support GHG reduction goals. To the full extent of its jurisdictional authority, the Town will implement GHG mitigation measures for both community and government operations comprising the following general categories:

> Natural Systems and Sequestration (excluding Carbon Offsets)

> Land Use and Transportation

> Green Building, Energy Efficiency and Renewable Energy

> Green Purchasing

> Waste Reduction, Recycling and Zero Waste

> State Actions

> Carbon Offsets

City of San Rafael

The City of San Rafael’s partnering in the *Marin County Climate Action Plan Update* (MCCDA 2014) supports its overall policy of reducing GHG emissions in concert with applicable city plans, goals, objectives, policies, and programs related to climate change. The new Sustainability (SU) and Conservation (CON) Elements of the General Plan (SRPD 2004) contain three main goals that aim to reduce direct and indirect GHG emissions: (1) to have a sustainable community, one that balances the needs of the environment, the economy and a diverse society; (2) to have municipal operations that are highly resource efficient and anticipate the effects of climate change; and (3) to have conservation and management of resources. Thirteen SU and CON policies support these goals (SRPD 2004).To the full extent of its jurisdictional authority, the City will:

> Implement General Plan land use policies to increase residential and commercial densities within walking distance of high frequency transit centers and corridors.

> Encourage decreasing miles traveled in single-occupant vehicles.

> Promote the use of alternative fuel and fuel-efficient vehicles.

> Reduce material consumption and waste generation, increase resource reuse and composting of organic waste, and recycle to significantly reduce and ultimately eliminate landfill disposal.

> Implement municipal programs to demonstrate the City's commitment to sustainability efforts and reducing GHGs.

> Encourage business, commercial property owners, apartment building owners, and nonprofit organizations to be resource, energy, and water efficient.

> Promote and encourage residences to be resource, energy, and water efficient by creating incentives and removing obstacles to promote their use.

> Support the development of renewable and/or efficient generating resources to reduce the County's reliance on nonrenewable energy supplies.

> Encourage water-conserving practices in businesses, homes, and institutions and increase the use of recycled water.

> Encourage recycling through provision of recycling containers, and developing and promoting both existing and new programs.

> Encourage site planning and development practices that reduce energy demand, support transportation alternatives, and incorporate resource- and energy-efficient infrastructure.

> Encourage the creation of programs such as Transportation Systems Management (TSM), public transit, carpools/ vanpools, ride-match, bicycling, and other alternatives to the energy-inefficient use of vehicles.

> Promote and serve as an effective leader in implementing conservation practices and incorporating resource-efficient alternatives in government faculties and services.

City of Sausalito

The City of Sausalito's partnering in the *Marin County Climate Action Plan Update* (MCCDA 2014) supports its overall policy of reducing GHG emissions in concert with applicable city plans, goals, objectives, policies, and programs related to climate change. The Environmental Quality (EQ) Element of the General Plan (mid-1990s) contains four GHG-related topics: Air Quality, Water Conservation, Energy Conservation, and Solid Waste Conservation and Recycling. Due to its apparent age (c. 20 years), the General Plan does not address GHGs or climate change per se; however, 11 EQ policies support GHG reduction goals (SPD 199X).[4] To the full extent of its jurisdictional authority, the City will:

> Implement Circulation and Parking Element programs which could reduce vehicular emissions.

> Encourage business and residential use of clean-burning fuels.

> Require vehicles purchased by the City to have low emissions and perform routine maintenance to ensure low emissions.

> Coordinate land use development review with the Marin Municipal Water District (MMWD) to ensure adequate water supplies.

> Continue to implement the local water conversation ordinance in coordination with the MMWD.

> Evaluate the use of reclaimed (treated) wastewater for irrigating City landscaping, median strips, and parks.

[4] The apparent 1990s-era document is undated.

> Coordinate with the MMWD and surrounding communities in discussion of and planning for future water supply and water quality.

> Convert incandescent street lighting to less energy-intensive fixtures in order to reduce energy consumptions and costs.

> Encourage new development to utilize passive solar energy methods to reduce energy consumption to the extent feasible consistent with other design considerations such as view retention, glare, and other requirements.

> Coordinate local recycling and related publicity efforts with the County Solid Waste Management Plan.

> Continue and expand the existing residential recycling program and establish a commercial recycling program in coordination with the Chamber of Commerce and local businesses.

Town of Tiburon

The Town of Tiburon's partnering in the *Marin County Climate Action Plan Update* (MCCDA 2014) supports its overall policy of reducing GHG emissions in concert with applicable city plans, goals, objectives, policies, and programs related to climate change. The Open Space & Conservation (OSC) Element of the General Plan (TPD 2005) contains four GHG-related topics: Water Supply Policies, Air Quality Policies, Solid Waste and Recycling Policies, and Green Building Policies. Due to its age (10 years), the General Plan does not address GHGs or climate change per se; however, nine OSC policies support GHG reduction goals (TPD 2005). To the full extent of its jurisdictional authority, the Town will:

> Support the efforts of the Marin Municipal Water District (MMWD) to conserve water through enforcement of the Town's water conservation ordinance requiring implementation of water conservation measures.

> Coordinate planning activities with the MMWD to ensure that both the Town and MMWD have the latest information with respect to land use and water supply planning.

> Participate in efforts to voluntarily reduce activities that pollute on Spare the Air days and help publicize Spare the Air activities.

> Encourage reduction of the number of single-occupant vehicle trips and cumulative [GHG] emissions that result from automobile use through implementation of Circulation Element policies.

> Continue to meet or exceed waste diversion targets set by the State of California.

> Require as a condition of approval of use permits that businesses prepare and implement waste management plans to maximize recycling, where appropriate.

> Continue to pursue opportunities to improve energy efficiency and reduce resource consumption in Town-owned facilities and operations.

> Apply green building principals to the design, construction, and operation of Town-sponsored facilities.

> Integrate energy efficiency, conservation, and other green building incentives into the zoning, permitting, and building processes.

11.1.7.3.4 Sonoma County and Cities Climate Change Related Policies

Notwithstanding air district CEQA guidelines on GHGs and climate change, many counties and cities in California have developed climate change policies and action plans, which are primarily used as planning and operations management tools. As planning tools, the general aim is to implement "smart growth" policies, prevent unmitigated sprawl, conserve energy and water, and reduce automobile dependence – all of which reduce climate impacts either directly or indirectly. As operations management tools, the general aim is to minimize direct and indirect GHG emissions from government operations, mainly through energy conservation.

Sonoma County

CEQA Guidelines

In Sonoma County, the CEQA Guidelines are followed for implementing CEQA. As such, CEQA Guidelines Appendix G, Environmental Checklist Form, Section VII (Greenhouse Gases) applies. Further, Chapter 8 of the General Plan Open Space and Resource Conservation Element acknowledges Section VII by defining several objectives related to climate change and GHGs. (SCPRMD 2010)

Sonoma County Community Climate Action Plan

The *Sonoma County Community Climate Action Plan* (SCCPC 2008) was prepared by the Sonoma County Climate Protection Campaign (SCCPC), a coalition of cities, agencies, foundations, and private citizens. The nine incorporated cities and towns include Cloverdale, Cotati, Healdsburg, Petaluma, Rohnert Park, Santa Rosa, Sebastopol, Sonoma, and Windsor. Participating agencies include the County of Sonoma, the Sonoma County Water Agency, the Sonoma County Transportation Authority, and the Sonoma County Agriculture Preservation and Open Space District.

The Climate Action Plan is organized by sector: Electricity and Natural Gas (including water, wastewater, efficiency, and new construction); Transportation and Land Use; Agriculture and Forests; and Solid Waste. Solutions for each sector were analyzed using four criteria: (1) potential for significant, rapid GHG emission reductions; (2) cost effectiveness; (3) ability to maintain local control; and (4) political feasibility. The Plan estimates the amount of GHG reductions and the required financial investment associated with each solution, and recommends the entities to implement the solutions. The Plan presents a package of solutions that, when implemented as a large-scale public works project, should meet the goal of reducing GHG emissions – 25 percent below 1990 levels by 2015. All nine Sonoma cities and the County established these goals in 2005. (SCCPC 2008)

Thus, by 2015 Sonoma County should reduce its emissions by 1.4 million metric tonnes (MMT) CO_2e from the "business as usual" total of 4.2 million tons to reach 2.8 MMT CO_2e by 2015, which equals the target of 25 percent below the 1990 emission level. Projections of contributions of the major solutions toward the total reduction (i.e., 1.4 MMT CO_2e) are based on the following assumptions (SCCPC 2008):

> Energy Efficiency: 80 percent of Sonoma County homes and commercial spaces retrofitted with all economically feasible efficiency improvements.

> Renewable Energy Production: Build a low carbon electricity portfolio with 67 percent new local renewables including natural gas replacement and efficiency retrofit.

> Transportation: Trip reduction, average trip length reduction, and shifting from single-occupant vehicles to public transit, walking, and bicycling; large-scale car share fleet of electric and plug-in hybrid vehicles.

Reasonable expectations for implementation of all major quantified solutions indicate that GHG emissions should reach about 22 percent below 1990 levels, which is about 37 percent below business as usual (SCCPC 2008). The remaining 3 percent of reductions would presumably come from minor miscellaneous sources.

General Plan

The Sonoma County General Plan Open Space and Resource Conservation (OSRC) Element contains Chapter 8, *Air Resources*. Chapter 8 states that the Geysers power plants are the largest stationary sources in Sonoma County. Other stationary sources include mining operations, industrial and agricultural activities, and lumber mills. Residential wood stoves are a major contributor to elevated wintertime particulate levels in urban areas in the north County. (SCPRMD 2010)

Chapter 8 contains several OSRC overall objectives and tailored policies related to climate change and GHGs. Seven of these include (SCPRMD 2010):

> Minimizing GHG (and criteria pollutant) emissions overall

> Encouraging reduced motor vehicle use as a means of reducing resultant emissions overall

> Requiring that development projects be designed to minimize GHG emissions

> Reducing indirect GHG emissions elsewhere (e.g., power plants) by utilizing construction techniques that decrease the need for space heating and cooling

> Encouraging public transit, ridesharing and van pooling, shortened and combined motor vehicle trips to work and services, use of bicycles, and walking in order to minimize single passenger motor vehicle use

> Encouraging the adoption of standards, the development of new technology, and retrofitting to reduce GHG and criteria emissions from geothermal development

> Requiring that traffic-inducing land use development projects within BAAQMD jurisdiction incorporate GHG and criteria pollutant mitigation measures in their design

City of Cloverdale

The City of Cloverdale's participation in the *Sonoma County Community Climate Action Plan* (SCCPC 2008) supports its overall goal of reducing GHG emissions in concert with applicable city plans, goals, objectives, policies, and programs related to climate change. The Conservation, Design, and Open Space (CDO) Element of the General Plan (CPCDD 2009) contains Goal CDO-8, which aims to conserve energy and minimize resource depletion by encouraging alternative energy, solar power, and green building techniques, thus reducing GHG emissions. Five CDO policies support this goal (CPCDD 2009). To the full extent of its jurisdictional authority, the City will:

> Use energy and resource efficient methods in daily City operation. Where feasible, use energy efficient transportation, locally generated solar and alternative power sources, and green building methods for City buildings.

> Use, support, and encourage energy and resource efficient methods in private construction. The Building Department will provide reviews and inspect using green building standards if requested by any applicant.

> Study and develop ordinances and incentives to encourage energy efficient transportation, locally generated solar and alternative power sources, and green building methods for private buildings and projects.

> Study and develop ordinances and incentives to encourage water conservation.

> Inventory and work to reduce GHG Emissions. The City shall work with the NSCAPCD, CARB, and/or other responsible agencies to prepare a Climate Action Plan.

City of Cotati

The City of Cotati's participation in the *Sonoma County Community Climate Action Plan* (SCCPC 2008) supports its overall goal of reducing GHG emissions in concert with applicable city plans, goals, objectives, policies, and programs related to climate change. The Conservation (CON) Element of the Draft General Plan Update (CPD 2013) contains Goal CON-2, which aims to reduce criteria pollutant and GHG emissions overall. More specifically, Objective CON-2B aims to reduce emissions of GHGs from city operations and community sources. Seven CON policies support this objective (CPD 2013). To the full extent of its jurisdictional authority, the City will:

> Reduce GHG emissions from City facilities and operations to 30 percent below 1990 levels by 2015, consistent with the goals stated in the 2008 Cotati GHG Emissions Reduction Action Plan.

> Continue to aggressively implement the GHG reduction measures contained in the 2008 Cotati GHG Emissions Reduction Action Plan.

> Support the development and implementation of a GHG reduction plan, or Climate Action Plan, that addresses and reduces GHG emissions associated with community operations, including but not limited to: mobile sources, energy consumption, and solid waste.

> Coordinate with Sonoma County and nearby cities to implement regional GHG reduction plans and consolidate efforts to reduce GHGs throughout the County.

> Encourage local businesses and industries to engage in voluntary efforts to reduce GHG emissions and energy consumption.

> Preserve, protect and enhance, as appropriate, the City's carbon sequestration resources, also referred to as "carbon sinks," to improve air quality and reduce net carbon emissions.

> Encourage public transit, ridesharing and van pooling, shortened and combined motor vehicle trips to work and services, use of bicycles, and walking. Minimize single passenger motor vehicle use.

City of Healdsburg

The City of Healdsburg's participation in the *Sonoma County Community Climate Action Plan* (SCCPC 2008) supports its overall policy of reducing GHG emissions in concert with applicable city plans, goals, objectives, policies, and programs related to climate change. The Natural Resources (NR) Element of the 2030 General Plan (HPD 2011) contains Goal NR-E, which aims to reduce GHG emissions and increase energy efficiency on a community-wide basis. Six NR policies support this goal (HPD 2011). To the full extent of its jurisdictional authority, the City will:

> Reduce GHGs produced community-wide.

> Reduce GHG emissions produced by internal municipal operations.

> Comply with California's Publicly Owned Electric Utilities' Principles Addressing GHG Reduction Goals.

> Support sustainable development and building practices and lead by example in municipal projects.

> Encourage the use of large-scale trees in new development to lessen heat build-up from solar radiation.

> Comply with state climate protection goals and programs to the maximum extent allowed by the City's jurisdictional authority.

City of Petaluma

The City of Petaluma's participation in the *Sonoma County Community Climate Action Plan* (SCCPC 2008) supports its overall policy of reducing GHG emissions in concert with applicable city plans, goals, objectives, policies, and programs related to climate change. The Natural Environment (NE) Element (Chapter 4) of the 2025 General Plan (PCDD 2008) contains Goal 4-G-6, which aims to reduce the contribution of GHGs to the atmosphere from existing sources and minimize the contribution of GHGs from new construction and sources. Eight NE policies support this goal (PCDD 2008). To the full extent of its jurisdictional authority, the City will:

> Fund and/or designate a Green Program Manager to oversee implementation of all GHG emissions policies and programs identified in the GHG emissions section as well as the City's Climate Action Plan.

> Comply with AB 32 and its governing regulations.

> Implement any additional adopted state legislative or regulatory standards, policies, and practices designed to reduce GHG emissions, as those measures are developed.

> Prepare a Community Climate Action Plan to identify and prioritize programs, projects, and procedural policies that will help the City achieve the community GHG emission goals of 25 percent below 1990 levels by 2015.

> Prepare an AB 117 feasibility report for the City of Petaluma forming a Community Choice Aggregation as a way of supplying renewable energy to the community.

> Train appropriate City staff on new technology and look for opportunities to improve energy efficiency in public facilities.

> Continue to monitor new technology and innovative sustainable design practices for applicability to insure future development minimizes or eliminates the use of fossil fuel and GHG-emitting energy consumption.

> Provide information and tips on reducing greenhouse gas emissions to the community.

City of Rohnert Park

The City of Rohnert Park's participation in the *Sonoma County Community Climate Action Plan* (SCCPC 2008) supports its overall policy of reducing GHG emissions in concert with applicable city plans, goals, objectives, policies, and programs related to climate change. The Environmental Conservation (EC) Element of the General Plan (RPPD 2000) contains Chapter 6.4 – *Air Quality*, which aims to reduce emissions of criteria pollutants, which also reduces GHGs emissions and combats climate change. Due to its age (14 years), the General Plan does not address GHGs or climate change per se. Six EC policies support this goal (RPPD 2000). To the full extent of its jurisdictional authority, the City will:

> Continue to work toward improving air quality and meeting all federal and state ambient air quality standards and by reducing the generation of air pollutants [and GHGs] both from stationary and mobile sources, where feasible.

> Encourage land use and transportation strategies that promote use of alternatives to the automobile for transportation, including bicycling, bus transit, and carpooling.

> Cooperate with the BAAQMD to achieve emissions reductions of nonattainment pollutants [and GHGs], including carbon monoxide, ozone, and PM-10, by implementation of air pollution control measures as required by state and federal statutes.

> Use the City's development review process and the California Environmental Quality Act (CEQA) regulations to evaluate and mitigate the local and cumulative effects of new development on air quality [and climate change].

> Prohibit [criteria pollutant and GHG] emission-generating facilities in the Northwest Specific Plan area or in the planned industrial areas in the southeast.

> Encourage new residential development and remodeled homes to install clean-burning fireplaces and wood stoves [to reduce emissions of particulate matter and GHGs].

City of Santa Rosa

The City of Santa Rosa's participation in the *Sonoma County Community Climate Action Plan* (SCCPC 2008) supports its overall policy of reducing GHG emissions in concert with applicable city plans, goals, objectives, policies, and programs related to climate change. The Open Space and Conservation (OSC) Element of the 2035 General Plan (SRCDD 2009) contains Goal OSC-K, which aims to reduce energy use in existing and new commercial, industrial, and public structures; Goal OSC-L, which encourages the development of nontraditional and distributed sources of electrical generation; and Goal OSC-M, which aims to reduce GHG emissions. Nine OSC policies support these goals (SRCDD 2009). To the full extent of its jurisdictional authority, the City will:

> Promote the use of site planning, solar orientation, cool roofs, and landscaping to decrease summer cooling and winter heating needs. Encourage the use of recycled content construction materials.

> Identify opportunities for decreasing energy use through installation of energy efficient lighting, reduced thermostat settings, and elimination of unnecessary lighting in public facilities.

> Identify and implement energy conservation measures that are appropriate for public buildings. Implement measures that are at least as effective as those in the retrofit ordinances for commercial and office buildings.

> Advance the city's environmentally sensitive preferred purchasing and green fleet conversion programs.

> Implement measures of the Climate Action Plan that increase energy efficiency, including retrofitting existing buildings and facilitating energy upgrades.

> Reconsider any existing codes and policies that constrain or prohibit the installation of environmentally acceptable forms of distributed generation.

> Participate in state and local efforts to develop appropriate policies and review procedures for the installation of photovoltaic solar and other environmentally acceptable forms of distributed generation.

> Establish a city renewable energy program that will allow the city to generate or receive a significant portion of energy from renewable sources.

> Meet local, regional, and state targets for reduction of GHG emissions through implementation of the Climate Action Plan.

City of Sebastopol

The City of Sebastopol's participation in the *Sonoma County Community Climate Action Plan* (SCCPC 2008) supports its overall policy of reducing GHG emissions in concert with applicable city plans, goals, objectives, policies, and programs related to climate change. The Conservation, Parks, and Open Space (CPOS) Element of the General Plan (SEPD 1994) contains Goal 6 – Energy Conservation and Goal 7 – Air Quality Improvement, which collectively aim to reduce direct and indirect emissions of criteria pollutants and GHGs. Due to its age (20 years), the General Plan does not address GHGs or climate change per se. Six CPOS policies support these goals (SEPD 1994). To the full extent of its jurisdictional authority, the City will:

> Implement energy conservation measures in new buildings. Reduce energy consumption by requiring structures to meet the energy conservation requirements in the Uniform Building Code and State of California Tile 24 regulations.

> Implement energy conservation measures in existing buildings. Encourage retrofitting of energy-saving features in existing dwellings as part of the City's housing rehabilitation program by providing information, technical assistance, and other incentives.

> Incorporate energy conservation in the development review process. Make energy conservation an important criterion in the development review process, e.g., solar access, energy efficiency features, utility-sponsored conservation programs.

> Participate in BAAQMD clean air and climate change planning processes.

> Promote trip reduction. Reduce the number of single-occupant vehicle trips and the number of vehicle-miles travelled within the planning area to reduce criteria pollutant [and GHG] emissions.

> Utilize the CEQA process to evaluate and mitigate the local and cumulative effects of new development on air quality [and climate change].

City of Sonoma

The City of Sonoma's participation in the *Sonoma County Community Climate Action Plan* (SCCPC 2008) supports its overall policy of reducing GHG emissions in concert with applicable city plans, goals, objectives, policies, and programs related to climate change. The Environmental Resources (ER) Element of the General Plan (SOPD 2006) contains Goal ER-3: Conserve natural resources to ensure their long-term sustainability. Sustainability, among other goals, aims to reduce direct and indirect emissions of GHGs; however, the General Plan does not address GHGs or climate change per se. Three ER policies support this goal (SOPD 2006). To the full extent of its jurisdictional authority, the City will:

> Increase the conservation-effectiveness and cost-effectiveness of the solid waste source reduction program through expanded recycling and composting.

> Encourage construction, building maintenance, landscaping, and transportation practices that promote energy and water conservation and reduce GHG emissions.

> Set an example of sustainability by conserving resources and following green practices in City facilities, services, and projects.

Town of Windsor

The Town of Windsor's participation in the *Sonoma County Community Climate Action Plan* (SCCPC 2008) supports its overall policy of reducing GHG emissions in concert with applicable city plans, goals, objectives, policies, and programs related to climate change. The Environmental Resources (ER) Element of the General Plan (WPD 1996) contains Goal 6.G – Air Quality and Goal 6.H – Energy Conservation. These sustainability goals aim to reduce direct and indirect emissions of GHGs; however, the General Plan does not address GHGs or climate change per se. Three ER policies support these goals (WPD 1996). To the full extent of its jurisdictional authority, the Town will:

> Comply with the state and federal ambient air quality standards and participate in regional efforts to improve air quality (and combat climate change).

> Encourage land use patterns and management practices that conserve air resources (and reduce GHG impacts).

> Encourage land use patterns and management practices that conserve energy resources (which reduce direct and indirect GHG emissions).

11.2 Environmental Impacts and Mitigations Measures

11.2.1 Evaluation Concerns and Criteria

The environmental concerns are those identified below from the CEQA Guidelines and from public scoping. The public identified the following issues:

> Address impacts on GHG emissions and climate change

The focus in this chapter is on the use of equipment to perform all Program activities and the resulting emissions impacts to generation of GHGs. The CEQA Guidelines are sufficient to cover the issues from public scoping.

As described in Section 11.1.7.3, no promulgated standards of significance exist for GHG impacts established under CEQA for mobile sources such as mosquito and vector control activities. The PEIR addresses the following qualitative criteria are used as standards of significance and are based on CEQA Guidelines Appendix G, Environmental Checklist Form, Section VII.

Would the project:

> Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment?

> Conflict with any applicable plan, policy, or regulation of an agency adopted for the purpose of reducing the greenhouse gas emissions?

Determinations made with respect to significance criteria are documented in Sections 11.2.3 through 11.2.8. See Section 11.1.7.3.1 for a discussion of CEQA thresholds of significance for GHGs.

11.2.2 Evaluation Methods and Assumptions

As described in Section 11.1.3, operation of onroad fleet vehicles, offroad all-terrain vehicles, watercraft, aircraft, portable equipment, and small equipment would result in GHG emissions in engine exhaust. Detailed lists of equipment, estimated usage, and emission calculations are provided in Appendix C. Equipment lists and annual activity schedules were provided by the District. Emission calculations were performed using the most recent and applicable emission factors published by CARB (2008a) and USEPA (2011a, 2012c, 2014).

Table 11-8 shows Program alternatives applicability by percentage: surveillance, physical control, vegetation management, biological control, chemical control, or other nonchemical control. Table 11-9 shows land uses associated with selected alternatives: residential, commercial, industrial, agricultural, and open space.

Table 11-8 Marin/Sonoma Mosquito and Vector Control District's Selected Alternatives Applicability

Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical
20%	5%	13%	21%	25%	15%

Source: Appendix C, Marin/Sonoma Mosquito and Vector Control District

Table 11-9 Land Uses Associated with Selected Alternatives for Marin/Sonoma Mosquito and Vector Control District

Residential	Commercial	Industrial	Agricultural	Open Space
•	•	•	•	•

Source: Marin/Sonoma Mosquito and Vector Control District

As described in Section 11.1.7.3, no promulgated standards of significance exist for GHG impacts established under CEQA for mobile sources such as mosquito and vector control activities. However, for evaluation purposes the estimated maximum annual Program emissions are compared to the 1,100 MT CO_2e per year significance threshold for projects that are not stationary sources, e.g., mosquito and vector control activities, as presumptive "land use" projects. The existing Program activities are the basis for the quantitative evaluation and if compared strictly to existing activities at the time the NOP was published (May 25, 2012), the impact would be no change. Future Program activities would be similar and not result in substantial emission changes over existing conditions.

Tables 11-10 through 11-15 show estimated ongoing annual GHG emissions as CO2e by alternative. On the local level, the Program alternatives combined "grand total" of 259 MT CO2e per year is below the presumptive 1,100 MT per year threshold and would be less than significant (LS) and would not be cumulatively considerable.

Table 11-10 Estimated Annual GHG Emissions for Surveillance Alternative for Marin/Sonoma Mosquito and Vector Control District

CO_2 MT/year	CH_4 MT/year	N_2O MT/year	CO_2e MT/year
51.0	0.0024	0.0016	51.6

Sources: CARB 2008a; USEPA 2011a, 2012c

Table 11-11 Estimated Annual GHG Emissions for Physical Control Alternative for Marin/Sonoma Mosquito and Vector Control District

CO_2 MT/year	CH_4 MT/year	N_2O MT/year	CO_2e MT/year
14.0	0.0007	0.0004	14.1

Sources: CARB 2008a; USEPA 2011a, 2012c

Table 11-12 Estimated Annual GHG Emissions for Vegetation Management Alternative for Marin/Sonoma Mosquito and Vector Control District

CO_2 MT/year	CH_4 MT/year	N_2O MT/year	CO_2e MT/year
34.5	0.0016	0.0011	34.8

Sources: CARB 2008a; USEPA 2011a, 2012c

Table 11-13 Estimated Annual GHG Emissions for Biological Control Alternative for Marin/Sonoma Mosquito and Vector Control District

CO_2 MT/year	CH_4 MT/year	N_2O MT/year	CO_2e MT/year
54.4	0.0026	0.0017	55.0

Sources: CARB 2008a; USEPA 2011a, 2012c

Table 11-14 Estimated Annual GHG Emissions for Chemical Control Alternative for Marin/Sonoma Mosquito and Vector Control District

CO_2 MT/year	CH_4 MT/year	N_2O MT/year	CO_2e MT/year
64.2	0.0030	0.0020	64.9

Sources: CARB 2008a; USEPA 2011a, 2012c

Table 11-15 Estimated Annual GHG Emissions for Other Nonchemical Alternative for Marin/Sonoma Mosquito and Vector Control District

CO_2 MT/year	CH_4 MT/year	N_2O MT/year	CO_2e MT/year
38.0	0.0018	0.0012	38.4

Sources: CARB 2008a; USEPA 2011a, 2012c

11.2.3 Surveillance Alternative

The Surveillance Alternative would be a continuation of existing activities currently practiced by the District using applicable techniques, equipment, vehicles, and watercraft. Surveillance involves monitoring mosquito and/or vector populations and habitat, their disease pathogens, and the human/vector interactions. Field counting/sampling and trapping are common mechanisms for surveillance. The environmental impact concerns are phrased as questions as follows for the Surveillance Alternative.

Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment?

GHG emissions from the Surveillance Alternative would be similar to the average emissions shown in Table 11-10. The Surveillance Alternative would emit approximately 52 MT CO_2e per year, which is below the presumptive 1,100 MT per year threshold and would be less than significant (LS). Due to its small scale and GHG mitigations, the Surveillance Alternative would not individually affect the environment or impede the state's ability to meet its 2020 GHG emission reduction goal because the incremental cumulative impact would not be considerable.

> **Impact GHG-1:** Based on estimated annual CO_2e emissions, the Surveillance Alternative would not result in a cumulatively considerable amount of GHGs, and neither would the incremental contribution of the District. Impacts would be **less than significant** and no mitigation is required.

Conflict with any applicable plan, policy, or regulation of an agency adopted for the purpose of reducing the greenhouse gas emissions?

On a statewide basis, agencies in California are in the process of implementing strategies to reduce GHG emissions pursuant to the Global Warming Solutions Act of 2006 (AB 32, Núñez, Chapter 488, Statutes of 2006), which requires that California reduce its statewide GHG emissions to 1990 levels by 2020. AB 32 required CARB to develop the Scoping Plan (2008b) in coordination with the CEC's Climate Action Team (2010). The Scoping Plan defines a comprehensive set of emission reduction measures such as energy efficiency, renewable energy, cap-and-trade, transportation measures, low-carbon fuels, and targeted GHG fees. Due to its small scale, the Surveillance Alternative would not conflict with state and local plans, policies, or regulations aimed at curbing GHG emissions.

> **Impact GHG-2:** Based on the general inclusion of Surveillance Alternative emissions in the local and statewide GHG emission inventories, the Surveillance Alternative would not conflict with applicable plans, policies, or regulations for reducing GHG emissions. Impacts would be **less than significant** and no mitigation is required.

11.2.4 Physical Control Alternative

The Physical Control Alternative would be a continuation of existing activities currently practiced by the District using applicable techniques, equipment, vehicles, and watercraft. This alternative involves managing vector habitat using source control and permanent control methods that do not use biological agents or chemical pesticides, such as ditch maintenance and water management. The environmental impact concerns are phrased as questions as follows for the Physical Control Alternative.

Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment?

GHG emissions from the Physical Control Alternative would be similar to the average emissions shown in Table 11-11. The Physical Control Alternative would emit approximately 14 MT CO_2e per year, which is below the presumptive 1,100 MT per year threshold and would be less than significant (LS). Due to its small scale and GHG mitigations, the Physical Control Alternative would not individually affect the environment or impede the state's ability to meet its 2020 GHG emission reduction goal because the incremental cumulative impact would not be considerable.

> **Impact GHG-3:** Based on estimated annual CO_2e emissions, the Physical Control Alternative would not result in a cumulatively considerable amount of GHGs, and neither would the incremental contribution of the District. Impacts would be **less than significant** and no mitigation is required.

Conflict with any applicable plan, policy, or regulation of an agency adopted for the purpose of reducing the greenhouse gas emissions?

On a statewide basis, agencies in California are in the process of implementing strategies to reduce GHG emissions pursuant to the Global Warming Solutions Act of 2006 (AB 32, Núñez, Chapter 488, Statutes of 2006), which requires that California reduce its statewide GHG emissions to 1990 levels by 2020. AB 32 required CARB to develop the Scoping Plan (2008b) in coordination with the CEC's Climate Action Team (2010). The Scoping Plan defines a comprehensive set of emission reduction measures such as energy efficiency, renewable energy, cap-and-trade, transportation measures, low-carbon fuels, and targeted GHG fees. Due to its small scale, the Physical Control Alternative would not conflict with state and local plans, policies, or regulations aimed at curbing GHG emissions.

> **Impact GHG-4:** Based on the general inclusion of Physical Control Alternative emissions in the local and statewide GHG emission inventories, the Physical Control Alternative would not conflict with applicable plans, policies, or regulations for reducing GHG emissions. Impacts would be **less than significant** and no mitigation is required.

11.2.5 Vegetation Management Alternative

The Vegetation Management Alternative would be primarily a continuation of existing activities currently practiced by the District using applicable techniques, equipment, vehicles, and watercraft. Vegetation management is used to reduce the habitat value for mosquitoes and other vectors and/or to provide access to sources of mosquito production. The District uses hand tools and sometimes heavy equipment to remove vegetation primarily in aquatic habitats. The District may also consider applying herbicides in the future to manage or remove vegetation. The environmental impact concerns are phrased as questions as follows for the Vegetation Management Alternative.

Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment?

GHG emissions from the Vegetation Management Alternative would be similar to the average emissions shown in Table 11-12. The Vegetation Management Alternative would emit approximately 35 MT CO_2e per year, which is below the presumptive 1,100 MT per year threshold and would be less than significant (LS). Due to its small scale and GHG mitigations, the Vegetation Management Alternative would not individually affect the environment or impede the state's ability to meet its 2020 GHG emission reduction goal because the incremental cumulative impact would not be considerable.

> **Impact GHG-5:** Based on estimated annual CO_2e emissions, the Vegetation Management Alternative would not result in a cumulatively considerable amount of GHGs, and neither would the incremental contribution of the District. Impacts would be **less than significant** and no mitigation is required.

Conflict with any applicable plan, policy, or regulation of an agency adopted for the purpose of reducing the greenhouse gas emissions?

On a statewide basis, agencies in California are in the process of implementing strategies to reduce GHG emissions pursuant to the Global Warming Solutions Act of 2006 (AB 32, Núñez, Chapter 488, Statutes of 2006), which requires that California reduce its statewide GHG emissions to 1990 levels by 2020. AB 32 required CARB to develop the Scoping Plan (2008b) in coordination with the CEC's Climate Action Team (2010). The Scoping Plan defines a comprehensive set of emission reduction measures such as energy efficiency, renewable energy, cap-and-trade, transportation measures, low-carbon fuels, and targeted GHG fees. Due to its small scale, the Vegetation Management Alternative would not conflict with state and local plans, policies, or regulations aimed at curbing GHG emissions.

> **Impact GHG-6:** Based on the general inclusion of Vegetation Management Alternative emissions in the local and statewide GHG emission inventories, the Vegetation Management Alternative would not conflict with applicable plans, policies, or regulations for reducing GHG emissions. Impacts would be **less than significant** and no mitigation is required.

11.2.6 Biological Control Alternative

The Biological Control Alternative would be a continuation of existing activities currently practiced by the District using applicable techniques, equipment, and vehicles. It currently involves the use of mosquito predators, specifically, mosquitofish (*Gambusia affinis*), as they are the only commercially available biological control agents at this time. The environmental impact concerns are phrased as questions as follows for the Biological Control Alternative:

Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment?

GHG emissions from the Biological Control Alternative would be similar to the average emissions shown in Table 11-13. The Biological Control Alternative would emit approximately 55 MT CO_2e per year, which

is below the presumptive 1,100 MT per year threshold and would be less than significant (LS). Due to its small scale and GHG mitigations, the Biological Control Alternative would not individually affect the environment or impede the state's ability to meet its 2020 GHG emission reduction goal because the incremental cumulative impact would not be considerable.

> **Impact GHG-7:** Based on estimated annual CO_2e emissions, the Biological Control Alternative would not result in a cumulatively considerable amount of GHGs, and neither would the incremental contribution of the District. Impacts would be **less than significant** and no mitigation is required.

Conflict with any applicable plan, policy, or regulation of an agency adopted for the purpose of reducing the greenhouse gas emissions?

On a statewide basis, agencies in California are in the process of implementing strategies to reduce GHG emissions pursuant to the Global Warming Solutions Act of 2006 (AB 32, Núñez, Chapter 488, Statutes of 2006), which requires that California reduce its statewide GHG emissions to 1990 levels by 2020. AB 32 required CARB to develop the Scoping Plan (2008b) in coordination with the CEC's Climate Action Team (2010). The Scoping Plan defines a comprehensive set of emission reduction measures such as energy efficiency, renewable energy, cap-and-trade, transportation measures, low-carbon fuels, and targeted GHG fees. Due to its small scale, the Biological Control Alternative would not conflict with state and local plans, policies, or regulations aimed at curbing GHG emissions.

> **Impact GHG-8:** Based on the general inclusion of Biological Control Alternative emissions in the local and statewide GHG emission inventories, the Biological Control Alternative would not conflict with applicable plans, policies, or regulations for reducing GHG emissions. Impacts would be **less than significant** and no mitigation is required.

11.2.7 Chemical Control Alternative

The Chemical Control Alternative would be a continuation of existing activities currently practiced by the District using applicable techniques, equipment, vehicles, watercraft, and aircraft. It involves the application of insecticides to reduce vector populations. The environmental impact concerns are phrased as questions as follows for the Chemical Control Alternative.

Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment?

GHG emissions from the Chemical Control Alternative would be similar to the average emissions shown in Table 11-14. The Chemical Control Alternative would emit approximately 65 MT CO_2e per year, which is below the presumptive 1,100 MT per year threshold and would be less than significant (LS). Due to its small scale and GHG mitigations, the Chemical Control Alternative would not individually affect the environment or impede the state's ability to meet its 2020 GHG emission reduction goal because the incremental cumulative impact would not be considerable.

> **Impact GHG-9:** Based on estimated annual CO_2e emissions, the Chemical Control Alternative would not result in a cumulatively considerable amount of GHGs, and neither would the incremental contribution of the District. Impacts would be **less than significant** and no mitigation is required.

Conflict with any applicable plan, policy, or regulation of an agency adopted for the purpose of reducing the greenhouse gas emissions?

On a statewide basis, agencies in California are in the process of implementing strategies to reduce GHG emissions pursuant to the Global Warming Solutions Act of 2006 (AB 32, Núñez, Chapter 488, Statutes of 2006), which requires that California reduce its statewide GHG emissions to 1990 levels by 2020. AB 32 required CARB to develop the Scoping Plan (2008b) in coordination with the CEC's Climate Action Team

(2010). The Scoping Plan defines a comprehensive set of emission reduction measures such as energy efficiency, renewable energy, cap-and-trade, transportation measures, low-carbon fuels, and targeted GHG fees. Due to its small scale, the Chemical Control Alternative would not conflict with state and local plans, policies, or regulations aimed at curbing GHG emissions.

> **Impact GHG-10:** Based on the general inclusion of Chemical Control Alternative emissions in the local and statewide GHG emission inventories, the Chemical Control Alternative would not conflict with applicable plans, policies, or regulations for reducing GHG emissions. Impacts would be **less than significant** and no mitigation is required.

11.2.8 Other Nonchemical Control/Trapping Alternative

As applicable, the Other Nonchemical Control/Trapping Alternative would be the District conducting limited trapping activities using applicable techniques, existing equipment, and existing vehicles. An example of these types of activities would be trapping of rodents and/or yellow jackets. The environmental impact concerns are phrased as questions as follows for the Other Nonchemical Control/Trapping Alternative.

Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment?

GHG emissions from the Other Nonchemical Control/Trapping Control Alternative would be similar to the average emissions shown in Table 11-15. The Other Nonchemical Control/Trapping Control Alternative would emit approximately 38 MT CO_2e per year, which is below the presumptive 1,100 MT per year threshold and would be less than significant (LS). Due to its small scale and GHG mitigations, the Other Nonchemical Control/Trapping Control Alternative would not individually affect the environment or impede the state's ability to meet its 2020 GHG emission reduction goal because the incremental cumulative impact would not be considerable.

> **Impact GHG-11:** Based on estimated annual CO_2e emissions, the Other Nonchemical Control/Trapping Control Alternative would not result in a cumulatively considerable amount of GHGs, and neither would the incremental contribution of the District. Impacts would be **less than significant** and no mitigation is required.

Conflict with any applicable plan, policy, or regulation of an agency adopted for the purpose of reducing the greenhouse gas emissions?

On a statewide basis, agencies in California are in the process of implementing strategies to reduce GHG emissions pursuant to the Global Warming Solutions Act of 2006 (AB 32, Núñez, Chapter 488, Statutes of 2006), which requires that California reduce its statewide GHG emissions to 1990 levels by 2020. AB 32 required CARB to develop the Scoping Plan (2008b) in coordination with the CEC's Climate Action Team (2010). The Scoping Plan defines a comprehensive set of emission reduction measures such as energy efficiency, renewable energy, cap-and-trade, transportation measures, low-carbon fuels, and targeted GHG fees. Due to its small scale, the Other Nonchemical Control/Trapping Control Alternative would not conflict with state and local plans, policies, or regulations aimed at curbing GHG emissions.

> **Impact GHG-12:** Based on the general inclusion of Other Nonchemical Control/Trapping Control Alternative emissions in the local and statewide GHG emission inventories, the Other Nonchemical Control/Trapping Control Alternative would not conflict with applicable plans, policies, or regulations for reducing GHG emissions. Impacts would be **less than significant** and no mitigation is required.

11.2.9 Cumulative Impacts

Cumulative impacts from Program alternative GHG emissions are discussed in Section 13.9. Cumulative impacts were assessed in a qualitative manner by determining if the Program alternatives, in conjunction with other approved plans, programs and projects throughout the Program Area, would have the potential to contribute to a long-term cumulative impact on climate change. Given that GHG emissions and climate change are global issues, a statewide framework or cumulative approach for consideration of environmental impacts may be most appropriate. Virtually every project in the state of California, as well as those outside the state, would have GHG emissions.

In developing thresholds of significance, BAAQMD considered the emission levels for which a project's individual emissions would be cumulatively considerable. Therefore, if a project would result in an increase in emissions at or above applicable mass thresholds, then it would be deemed to have a cumulatively considerable impact. Conversely, if a project would not exceed the significance thresholds, then its emissions would not be cumulatively considerable. (BAAQMD 2011)

In summary, all Program alternatives would generate GHG emissions and incrementally contribute to climate change, however minor. When all Program emissions are viewed in combination with global emissions levels that are contributing to the existing cumulative impact on global climate change, the incremental contribution of the Program emissions would not be cumulatively considerable because they occur intermittently on a very small scale (i.e., not stationary sources) and are nevertheless below the presumptive 1,100 MT per year threshold. Therefore, the Program alternatives would not have a cumulatively considerable impact on global climate change. BMPs (see Section 11.2.11) as implemented will reduce Program impacts even further.

11.2.10 Environmental Impacts Summary

Table 11-16 presents a summary of GHG impacts associated with the six alternatives in comparison to existing conditions defined as existing GHG inventories as well as existing conditions as of May-June 2012. The GHG impact callouts correspond to those in Sections 11.2.3 through 11.2.8.

Table 11-16 Summary of Greenhouse Gas Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Effects on GHG						
Impact GHG-1: Based on estimated annual CO2e emissions, the Surveillance Alternative would not result in a cumulatively considerable amount of GHGs, and neither would the incremental contribution of the District. Impacts would be **less than significant** and no mitigation is required.	LS	na	na	na	na	na
Impact GHG-2: Based on the general inclusion of Surveillance Alternative emissions in the local and statewide GHG emission inventories, the Surveillance Alternative would not conflict with applicable plans, policies, or regulations for reducing GHG emissions. Impacts would be **less than significant** and no mitigation is required.	LS	na	na	na	na	na
Impact GHG-3: Based on estimated annual CO2e emissions, the Physical Control Alternative would not result in a cumulatively considerable amount of GHGs, and neither would the incremental contribution of the District. Impacts would be **less than significant** and no mitigation is required.	na	LS	na	na	na	na
Impact GHG-4: Based on the general inclusion of Physical Control Alternative emissions in the local and statewide GHG emission inventories, the Physical Control Alternative would not conflict with applicable plans, policies, or regulations for reducing GHG emissions. Impacts would be **less than significant** and no mitigation is required.	na	LS	na	na	na	na
Impact GHG-5: Based on estimated annual CO2e emissions, the Vegetation Management Alternative would not result in a cumulatively considerable amount of GHGs, and neither would the incremental contribution of the District. Impacts would be **less than significant** and no mitigation is required.	na	na	LS	na	na	na
Impact GHG-6: Based on the general inclusion of Vegetation Management Alternative emissions in the local and statewide GHG emission inventories, the Vegetation Management Alternative would not conflict with applicable plans, policies, or regulations for reducing GHG emissions. Impacts would be **less than significant** and no mitigation is required.	na	na	LS	na	na	na

Table 11-16 Summary of Greenhouse Gas Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact GHG-7: Based on estimated annual CO2e emissions, the Biological Control Alternative would not result in a cumulatively considerable amount of GHGs, and neither would the incremental contribution of the District. Impacts would be **less than significant** and no mitigation is required.	na	na	na	LS	na	na
Impact GHG-8: Based on the general inclusion of Biological Control Alternative emissions in the local and statewide GHG emission inventories, the Biological Control Alternative would not conflict with applicable plans, policies, or regulations for reducing GHG emissions. Impacts would be **less than significant** and no mitigation is required.	na	na	na	LS	na	na
Impact GHG-9: Based on estimated annual CO2e emissions, the Chemical Control Alternative would not result in a cumulatively considerable amount of GHGs, and neither would the incremental contribution of the District. Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	LS	na
Impact GHG-10: Based on the general inclusion of Chemical Control Alternative emissions in the local and statewide GHG emission inventories, the Chemical Control Alternative would not conflict with applicable plans, policies, or regulations for reducing GHG emissions. Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	LS	na
Impact GHG-11: Based on estimated annual CO2e emissions, the Other Nonchemical Control/Trapping Control Alternative would not result in a cumulatively considerable amount of GHGs, and neither would the incremental contribution of the District. Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	na	LS

Table 11-16 Summary of Greenhouse Gas Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact GHG-12: Based on the general inclusion of Other Nonchemical Control/Trapping Control Alternative emissions in the local and statewide GHG emission inventories, the Other Nonchemical Control/Trapping Control Alternative would not conflict with applicable plans, policies, or regulations for reducing GHG emissions. Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	na	LS

LS = Less-than-significant impact

N = No impact

na = Not applicable

SM = Potentially significant but mitigable impact

SU = Significant and unavoidable impact

11.2.11 Mitigation and Monitoring

All impacts are less than significant (LS) compared to existing conditions and require no mitigation. The District will reduce small impacts even further (under Impacts GHG-1, GHG-3, GHG-5, GHG-7, GHG-9, and GHG-11), as described below based on BMP A14 in Table 2-6.

Notwithstanding significance BMPs pursuant to California Air Toxics Control Measures (13 CCR §2485) and In-Use Off-Road Diesel Vehicle Regulations (13 CCR §2449 et seq.) will also minimize criteria pollutant and GHG emissions from diesel and gasoline engine exhaust. The District and its contractors will implement the following BMPs as part of the Program:

- Idling times shall be minimized either by shutting equipment and vehicles off when not in use or reducing the maximum idling time to 5 minutes.
- Correct tire inflation shall be maintained in accordance with manufacturer‘s specifications on wheeled equipment and vehicles to prevent excessive rolling resistance.
- All equipment and vehicles shall be maintained and properly tuned in accordance with manufacturer‘s specifications. All equipment shall be checked by a certified visible emissions evaluator if visible emissions are apparent to onsite staff.

Also, where practicable and available, the Program will use alternatively fueled equipment, such as compressed natural gas (CNG), liquefied natural gas (LNG), liquefied petroleum/propane gas (LPG), or biodiesel.

12 Noise

Chapter 12-evaluates potential noise impacts from Program implementation on human receptors. Impacts of Program noise on fish and wildlife are addressed in Chapter 4, *Biological Resources – Aquatic*, and Chapter 5, *Biological Resources – Terrestrial*. Results of the evaluations are provided at a programmatic level. Section 12.1, Environmental Setting, presents an overview of the physical properties and environmental noise; and contains federal, state, and local ordinances, plans, and regulations that are applicable to the Program. Section 12.2, Environmental Impacts and Mitigation Measures, presents the following:

> Environmental concerns and evaluation criteria used to determine whether the Program alternatives would cause significant impacts on noise levels throughout the region

> Evaluation methods and assumptions

> Discussion of noise impacts of the Program alternatives

> Cumulative impacts summary

> A summary of environmental impacts due to noise

Table 2-5 in Section 2.6 presents the District's list of equipment that could generate noise. Handheld equipment is not included in this table. Appendix D, *Noise Analysis Technical Report*, includes additional detailed information regarding the physical properties of noise; federal, state, and local noise regulations; and equipment use noise generated by each of the Program alternatives.

12.1 Environmental Setting

12.1.1 Overview of Environmental Sound

Noise may be defined as unwanted sound. Noise is usually objectionable because it is disturbing or annoying. Several noise measurement scales are used to describe noise in a particular location. A decibel (dB) is a unit of measurement that indicates the relative Amplitude of a sound. The zero on the decibel scale is based on the lowest sound level that the healthy, unimpaired human ear can detect. Sound levels in decibels are calculated on a logarithmic basis. An increase of 10 dB represents a 10-fold increase in acoustic energy, while 20 dB is 100 times more intense, 30 dB is 1,000 times more intense, etc. A relationship exists between the subjective noisiness or loudness of a sound and its intensity. Each 10-dB increase in sound level is perceived as approximately a doubling of loudness over a fairly wide range of intensities.

Several methods are used to characterize sound. The most common is the A-weighted sound level, or dBA. This scale gives greater weight to the frequencies of sound to which the human ear is most sensitive. Because sound levels can vary markedly over a short period of time, a method for describing either the average character of the sound or the statistical behavior of the variations must be used. Most commonly, sounds are described in terms of an average level that has the same acoustical energy as the summation of all the time-varying events. This energy-equivalent sound/noise descriptor is called L_{eq}. The most common averaging period is hourly, but L_{eq} can describe any series of noise events of arbitrary duration.

Because the sensitivity to noise increases during the evening and at night—excessive noise interferes with the ability to sleep—24-hour descriptors have been developed that incorporate artificial noise penalties added to quiet-time noise events. The Community Noise Equivalent Level (CNEL) is a measure of the cumulative noise exposure in a community, with a 5-dB penalty added to evening (7:00 PM to 10:00 PM) and a 10-dB addition to nocturnal (10:00 PM to 7:00 AM) noise levels. The day/night average sound level (L_{dn}) is essentially the same as CNEL, with the exception that the evening time period is dropped and all occurrences during this 3-hour period are grouped into the daytime period.

Noise changes both in level and frequency spectrums as it travels from the source to the receiver. The most obvious is the decrease in noise as the distance from the source increases. The manner in which noise is reduced depends on a variety of factors, including the noise source type as well as the region over which the noise source propagates. Noise generated by a point source, such as equipment at a construction site, drops off at a rate of 6 dBA per doubling of distance. Traffic noise attenuates, or is reduced, at a different rate. The movement of vehicles makes the noise source appear to emanate from a line as opposed to a single point when viewed over a period of time. Noise levels drop-off at a rate of about 3 dBA per doubling of distance for this type of source near hard surfaces, such as paved areas or bodies of water. However, ground type also plays into how much of a drop off over distance will occur. Surfaces, such as plowed fields, crops, or grass, absorb some of the sound energy as the sound passes over; therefore, noise is reduced by 4.5 dBA for every doubling of the distance in such areas.

12.1.2 Community Noise Levels

Community noise levels depend on the intensity of nearby human activity. Noise levels are generally considered low when ambient levels are below 45 dBA, moderate in the 45- to 60-dBA range, and high above 60 dBA. In rural and undeveloped areas, L_{dn} can fall below 35 dBA. Levels above 75 to 80 dBA are more common near major freeways and airports. Although people often accept the higher levels associated with very noisy urban areas, they nevertheless are considered to be adverse to public health. The human pain threshold for sound is 120 dBA.

Typical noise levels from both mobile and stationary sources are included in Table 12-1.

Table 12-1 Typical Stationary and Mobile Noise Source Sound Levels in dBA

Noise Source	Sound Level in dBA
Sprayer, handheld	**10-20**
Noise at ear level from rustling leaves	20
Room in a quiet dwelling at midnight	32
Soft whisper at 5 feet	34
Large department store	50 to 65
Room with window air conditioner	55
Leaf blower/vac	**55-105**
Conversational speech	60 to 75
Pump station equipment with noise abatement	62
Sprayer, powered, truck- or trailer-mounted	**65-105**
Passenger car at 50 feet	69
Vacuum cleaner in private home at 10 feet	69
Tractor, agricultural	**76-110**
Ringing alarm at 2 feet	80
Brush/weed cutter	**90-97**
Roof-top air conditioner	85
Small bulldozer (Cat D3) or excavator (Cat 320)	**74-80**
Heavy bulldozer at 50 feet	87
All-terrain vehicle (ATV)	87-109

Table 12-1 Typical Stationary and Mobile Noise Source Sound Levels in dBA

Noise Source	Sound Level in dBA
Heavy city traffic	90
Lawn mower	**91-98**
Chainsaw	**100-120**
Jet aircraft at 500 feet overhead	115
Construction blast	120 to 145 at 50 feet

Sources: Equipment manufacturer specification sheets, Noise Control Reference Handbook, Industrial Acoustics Company

Note:

Bold indicates equipment used in the Program. Sound levels are measured at 50 feet from the source unless otherwise noted.

12.1.3 Noise Level Acceptance Criteria

The surrounding land uses dictate what noise levels would be considered acceptable or unacceptable. In rural and undeveloped areas away from roads and other human activity, the day-to-night difference is normally small. Because of diurnal activity, nighttime ambient levels in urban environments are about 7 dB lower than the corresponding daytime levels. Nighttime noise is a concern because of the likelihood of disrupting sleep. Noise levels above 45 dBA at night can result in the onset of sleep interference. At 70 dBA, sleep interference effects become considerable (USEPA 1974).

12.1.4 Sensitive Receptors

Some land uses are generally regarded as being more sensitive to noise than others due to the types of population groups or activities involved. The definition of sensitive receptors varies by jurisdiction, but in general sensitive population groups include children and the elderly and sensitive land uses include residential (single- and multifamily, mobile homes, dormitories, and similar uses), guest lodging, parks and outdoor recreation areas, hospitals, nursing homes and other long-term medical care facilities, and educational facilities, including schools, libraries, churches, and places of public assembly.

12.1.5 Regulatory Setting

Federal and state guidelines and local ordinances pertaining to environmental noise within the District's Service Area are cited in this section.

12.1.5.1 Federal Regulations

The federal noise standards or guidelines discussed in this section are relevant to the implementation of Program alternatives. Noise regulations and standards are provided for the following agencies:

> USEPA

> Federal Aviation Administration (FAA)

12.1.5.1.1 US Environmental Protection Agency

The USEPA has developed guidelines on recommended maximum long-term noise levels to protect public health and welfare (USEPA 1974). The USEPA does not enforce these guidelines, but rather offers them as a planning tool for state and local agencies. Table 12-2 provides examples of protective noise levels recommended by the USEPA. They are applicable to noise generated on federal lands, such as national wildlife refuges.

Table 12-2 USEPA-Designated Long-Term Noise Safety Levels

Effects	Noise Level	Area
Hearing Loss	$L_{eq}(24) < 70$ dB	All areas
Outdoor Activity Interference and Annoyance	$L_{dn} < 55$ dB	Outdoors in residential areas and farms and other outdoor areas where people spend widely varying amounts of time and other places in which quiet is a basis for use.
	L_{eq} (24) <55 dB	Outdoor areas where people spend limited amounts of time, such as schoolyards, playgrounds, etc.
Indoor Activity Interference and Annoyance	$L_{dn} < 45$ dB	Indoor residential areas
	$L_{eq}(24) < 45$ dB	Other indoor areas with human activities such as schools, etc.

Source: USEPA 1974

Notes:

L_{eq} (24) = sound energy averaged over a 24-hour period.

L_{dn} = L_{eq} with a 10-dB nighttime weighting.

12.1.5.1.2 Federal Aviation Administration

The major parts of CFR Title 14: Aeronautics and Space, Chapter I: Federal Aviation Administration, Department of Transportation, Subchapter C, for fixed-wing aircraft noise and Subchapter H for helicopter noise, were reviewed for applicability to Program flight operations, specifically:

Part 91: Flight Operations

Portions of Part 91 are provided to describe operational restrictions associated with different aircraft types. Altitude limitations governing agricultural operations are given in Part 137, Agricultural Operations. They are included because the FAA considers aerial spraying to be an agricultural use, even if it is not specifically used for agricultural purposes.

Fixed-wing aircraft not operating under Instrument Flight Rules, emergencies, during takeoff or landing, or Part 137 are required to maintain the altitudes listed in Section 91.119 - Minimum Safe Altitudes: General (a)-(d). Section 91.119 (a), (b), and (c) are provided below.

Except when necessary for takeoff or landing, no person may operate an aircraft below the following altitudes:

a. Anywhere. An altitude allowing, if a power unit fails, an emergency landing without undue hazard to persons or property on the surface.

b. Over Congested Areas. Over any congested area of a city, town, or settlement, or over any open-air assembly of persons, an altitude of 1,000 feet above the highest obstacle within a horizontal radius of 2,000 feet of the aircraft.

c. Over Other than Congested Areas. An altitude of 500 feet above the surface, except over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500 feet to any person, vessel, vehicle, or structure.

Section 137.49 – Operations over other than Congested Areas

Notwithstanding Part 91 of this chapter, during the actual dispensing operation, including approaches, departures, and turnarounds reasonably necessary for the operation, an aircraft may be operated over other than congested areas below 500 feet above the surface and closer than 500 feet to persons,

vessels, vehicles, and structures, if the operations are conducted without creating a hazard to persons or property on the surface.

Section 137.51 – Operation over Congested Areas: General

(a) Notwithstanding Part 91 of this chapter, an aircraft may be operated over a congested area at altitudes required for the proper accomplishment of the agricultural aircraft operation if the operation is conducted:

(1) With the maximum safety to persons and property on the surface, consistent with the operation, and

(2) In accordance with the requirements of paragraph (i) of this section

(i) No person may operate an aircraft over a congested area except in accordance with the requirements of this paragraph.

(3) Prior written approval must be obtained from the appropriate official or governing body of the political subdivision over which the operations are conducted.

(4) Notice of the intended operation must be given to the public by some effective means, such as daily newspapers, radio, television, or door-to-door notice.

(5) A plan for each complete operation must be submitted to, and approved by appropriate personnel of the FAA Flight Standards District Office having jurisdiction over the area where the operation is to be conducted. The plan must include consideration of obstructions to flight, the emergency landing capabilities of the aircraft to be used, and any necessary coordination with air traffic control.

(6) Single engine aircraft must be operated as follows:

(i) Except for helicopters, no person may take off a loaded aircraft, or make a turnaround over a congested area.

(ii) No person may operate an aircraft over a congested area below the altitudes prescribed in Part 91 of this chapter except during the actual dispensing operation, including the approaches and departures necessary for that operation.

(iii) No person may operate an aircraft over a congested area during the actual dispensing operation, including the approaches and departures for that operation, unless it is operated in a pattern and at such an altitude that the aircraft can land, in an emergency, without endangering persons or property on the surface.

(7) Multiengine aircraft must be operated as follows:

(i) No person may take off a multiengine airplane over a congested area except under conditions that will allow the airplane to be brought to a safe stop within the effective length of the runway from any point on takeoff up to the time of attaining, with all engines operating at normal takeoff power, 105 percent of the minimum control speed with the critical engine inoperative in the takeoff configuration or 115 percent of the power-off stall speed in the takeoff configuration, whichever is greater, as shown by the accelerate stop distance data. In applying this requirement, takeoff data is based upon still-air conditions, and no correction is made for any uphill gradient of 1 percent or less when the percentage is measured as the difference between elevations at the end points of the runway divided by the total length. For uphill gradients greater than 1 percent, the effective takeoff length of the runway is reduced 20 percent for each 1 percent grade.

(ii) No person may operate a multiengine airplane at a weight greater than the weight that, with the critical engine inoperative, would permit a rate of climb of at least 50 feet per minute at an altitude of at least 1,000 feet above the elevation of the highest ground or obstruction within the area to be worked or at an altitude of 5,000 feet, whichever is higher. For the purposes of this subdivision, it is assumed that the propeller of the inoperative engine is in the minimum drag position, that the wing flaps and landing gear are in the most favorable positions, and that the remaining engine or engines are operating at the maximum continuous power available.

(iii) No person may operate any multiengine aircraft over a congested area below the altitudes prescribed in Part 91 of this chapter except during the actual dispensing operation, including the approaches, departures, and turnarounds necessary for that operation.

Section 137.53 – Operation over Congested Areas: Pilots and Aircraft

(a) General. No person may operate an aircraft over a congested area except in accordance with the pilot and aircraft rules of this section.

(b) Pilots. Each pilot in command must have at least:

(1) 25 hours of pilot-in-command flight time in the make and basic model of the aircraft, at least 10 hours of which must have been acquired within the preceding 12-calendar months.

(2) 100 hours of flight experience as pilot in command in dispensing agricultural materials or chemicals.

(c) Aircraft

(1) Each aircraft must:

(i) If it is an aircraft not specified in paragraph (c)(1)(ii) of this section, have had within the preceding 100 hours of time in service a 100-hour or annual inspection by a person authorized by Part 65 or 145 of this chapter, or have been inspected under a progressive inspection system.

(ii) If it is a large or turbine-powered multiengine civil airplane of U.S. registry, have been inspected in accordance with the applicable inspection program requirements of Section 91.409 of this chapter.

(2) If other than a helicopter, it must be equipped with a device capable of jettisoning at least one-half of the aircraft's maximum authorized load of agricultural material within 45 seconds. If the aircraft is equipped with a device for releasing the tank or hopper as a unit, there must be a means to prevent inadvertent release by the pilot or other crewmember.

12.1.5.2 State Regulations

California Government Code Section 65302(f) encourages each local government entity to conduct noise studies and implement a noise element as part of its General Plans. In addition, the California Office of Planning and Research published guidelines for evaluating the compatibility of various land uses as a function of community exposure to permanent or long-term noise sources, and they are listed in Table 12-3. In general, noise levels less than 60-dBA L_{dn} are acceptable for all land uses, including residences, schools, and other noise-sensitive receptors. These guidelines are contained in the Marin Countywide Plan, Built Environment Element, Noise, Figure 3-41 (Marin County 2007).

Table 12-3 Land Use Compatibility for Community Noise Environment

Land Use Category	Community Noise Exposure – L_{dn} or CNEL in dBA						
	50	55	60	65	70	75	80
Residential – Low-Density Single Family, Duplex, Mobile Home							
Residential – Multifamily							
Transient Lodging – Motel, Hotel							
Schools, Libraries, Churches, Hospitals, Nursing Homes							
Auditorium, Concert Hall, Amphitheaters							
Sports Arena, Outdoor Spectator Sports							
Playgrounds, Neighborhood Parks							
Golf Courses, Riding Stables, Water Recreation, Cemeteries							
Office Buildings, Business Commercial and Professional							
Industrial, Manufacturing, Utilities, Agriculture							

Legend

	Normally Acceptable: Specified land use is satisfactory, based upon the assumption that any buildings involved are of normal conventional construction, without any special noise insulation requirements.
	Conditionally Acceptable: New construction or development should be undertaken only after a detailed analysis of the noise reduction requirements is made and needed noise insulation features are included in the design.
	Normally Unacceptable: New construction or development should be discouraged. If new construction or development does proceed, a detailed analysis of the noise reduction requirement must be made and needed noise insulation features included in the design.
	Clearly Unacceptable: New construction or development generally should not be undertaken.

Source: State of California, Office of Planning and Research, 1998 General Plan Guidelines

CNEL = Community Noise Equivalent Level

dBA = A-weighted decibel(s)

L_{dn} = Day-Night Noise Level

12.1.5.3 Local Regulations

A listing of local county plans and city and county noise ordinances for Marin and Sonoma counties and the cities located within these counties, and relevant provisions are summarized in Table 12-4. Cities and counties in California are required to include a noise element in their general plans, which include policies intended to achieve noise compatibility between land uses. These policies typically establish average noise levels that are acceptable at different land uses and are usually the same as or similar to those recommended by the state. The standards established in the noise elements for the Service Area are intended to establish land-use compatibility for planning purposes and are not intended to address temporary and sporadic sources of noise such as would be generated by the Proposed Program (IVMP) addressed in this PEIR. Noise elements are, therefore, not discussed further.

Most jurisdictions within the Service Area specify allowable hours for construction and specify allowable noise levels resulting from construction during certain times of day. Although the District's IVMP does not include construction per se, some alternatives use construction-type equipment, such as trucks and tractors, and like construction, would cause temporary impacts. Therefore, construction noise standards are used as a method to describe allowable temporary noise. Some jurisdictions have exemptions for certain types of emergency work, but the IVMP generally does not fall under their definitions of emergency work.

12.2 Environmental Impacts and Mitigation Measures

The noise impacts evaluation is provided below. The evaluation qualitatively and quantitatively compares probable noise levels against the impact significance criteria presented in Section 12.2.1.

12.2.1 Evaluation Concerns and Criteria

Temporary noise increases within the Program Area would be associated with the use of vehicles, backpack sprayers and ancillary equipment, sprayers, boats, heavy equipment, and aerial applications similar to current use of this equipment.

For this evaluation, impacts from Program noise sources would be considered significant if noise levels would:

> Expose people to or generate noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies. Because of the large number of local jurisdictions involved, the state's long-term land use compatibility guidelines, shown in Table 12-3, are used as a surrogate for land use compatibility standards in local general plans.

> Result in a substantial temporary increase in ambient noise levels above levels existing without the Program.

The CEQA Guidelines, and most cities and counties, do not provide a definition of what constitutes a substantial noise increase for the second bullet point above. A common practice has been to assume that minimally perceptible to clearly noticeable increases of 3 to 5 dBA represent a significant increase in ambient noise levels. A sliding scale is commonly used to identify the significance of noise increases, allowing greater increases at lower absolute sound levels than at higher sound levels. This approach is based on research that relates changes in noise to the percentage of individuals that would be highly annoyed by the change (Federal Interagency Committee on Noise 1992). The significance criteria for changes in noise from Program operations would be a 3-dBA CNEL increase in noise levels if the existing noise level already exceeds the acceptable range for the land use, or a 5-dBA CNEL increase in noise if the existing noise level is in the acceptable range and the resulting level remains within the acceptable range for the land use.

Table 12-4 Marin and Sonoma County Summary of Local Noise Standards

Jurisdiction	Source	Standards	Applicability to Project	URL
Marin County	Marin Countywide Plan 2007, Built Environment Element, Noise	**Goal NO-1 Protection from Excessive Noise**. Ensure that new land uses, transportation activities, and construction do not create noise levels that impair human health or quality of life.	Not applicable because the focus of the policy is on new development, not existing uses and activities.	http://www.co.marin.ca.us/depts/cd/main/fm/cwpdocs/CWP_CD2.pdf
Marin County	Municipal Code 6.70.030	Establishes hours for construction activities and other work undertaken in connection with building, plumbing, electrical, and other permits issued by the community development agency:	Not applicable because no permits are required from the community development agency.	https://www.municode.com/library/ca/marin_county/codes/code_of_ordinances?nodeId=TIT6PUPESAMO_CH6.70LOUNNO
Belvedere	Municipal Code 8.10	**8.10.010 Purpose**. It is hereby declared to be the policy of the City of Belvedere, in the exercise of its police power, to protect the peace, health, safety, and general welfare of the citizens of Belvedere from excessive, unnecessary and unreasonable noises. The provisions of this Chapter and the remedies contained in this Code shall be cumulative and are not intended to replace any otherwise available remedies for public or private nuisances, nor any other civil or criminal remedies otherwise available. In addition, the regulations contained herein are not intended to substitute for any noise analysis conducted as a part of the City's environmental review process for discretionary permit approvals, nor is it intended to limit more strict noise control requirements for discretionary permit approvals should more strict measures be found to be necessary in order to maintain noise levels that are not detrimental to the health and welfare of the citizens of the City. (Ord. 2006-3 § 3 (part), 2006.) **8.10.020 Prohibition against excessive noise**. It is unlawful for any person to willfully make or continue, or cause to be made or continued, any loud, unnecessary or unusual noise which disturbs the peace or quiet of any neighborhood or which causes discomfort or annoyance to any reasonable person of normal sensitivity residing in the area, and it is unlawful for any person in ownership or control of any premises to knowingly permit a violation of this section upon said premises. (Ord. 2006-3 § 3 (part), 2006.) **8.10.040 Prohibited noise generation**. Loud, unnecessary or unusual noises prohibited by Section 8.10.020 shall include, but not be limited to, the following: B. Power and construction tools. Using, operating or permitting to be used or operated, any power tool or construction tool in such manner as to unreasonably disturb the peace, quiet and comfort of a reasonable person of normal sensitivity residing in the area. Notwithstanding the foregoing, the use of power or construction tools in connection with a valid building permit issued by the City shall be subject to the terms and conditions and laws applicable to that permit. **8.10.050 Prima facie violations during quiet time.** The conduct of any loud, unnecessary or unusual noises prohibited by section 8.10.020 between the hours of 9 PM and 7 AM Sunday through Thursday and 11 PM to 7 AM Friday and Saturday in such a manner as to be plainly audible at a distance of fifty (50) yards from the structure, vehicle, or premises in which it is located shall be prima facie evidence of a violation of this Chapter. (Ord. 2006-3 § 3 (part), 2006.)	Provides "quiet time" hours whereby noise sources audible at 50 yards are prohibited.	http://www.cityofbelvedere.org/DocumentCenter/Home/View/368
Corte Madera	Code of Ordinances, Title 9 – Peace, Safety and Morals, Chapter 9.36.	(c) The provisions of subsection (a) shall not apply to construction or demolition work performed during the following times: Monday through Fridays from seven AM to five PM; and Saturdays and Sundays from ten AM to five PM; provided, that all powered construction equipment is equipped with intake and exhaust mufflers recommended by the manufacturers thereof; and provided, further, pavement breakers and jackhammers shall also be equipped with acoustical attenuating shields or shrouds recommended by the manufacturers thereof. In lieu of or in the absence of manufacturer's recommendations, the town engineer shall have the authority to prescribe such means of accomplishing maximum noise attenuation as he deems to be in the public interest, considering the available technology and economic feasibility.	Provides exemption for construction work between times listed. Requires certain noise mitigating equipment to be installed construction equipment.	https://library.municode.com/index.aspx?clientId=16293
Fairfax	Municipal Code 8.20.070	**§ 8.20.070 EXEMPTIONS.** D. Operating or permitting the operation of any mechanically powered tools or equipment for construction, demolition or property maintenance work between 8:00 AM and 6:00 PM Monday through Friday, and 9:00 AM to 4:00 PM on weekends and holidays are exempt. E. Anyone operating mechanically powered tools during permitted hours shall use best practices to minimize flying dust and debris and to protect neighbors, pedestrians and others nearby from disturbed particulate matter. **§ 8.20.060 PROHIBITED ACTS.** 2. Operating or permitted the operation of any mechanically powered tools between the hours of 6:00 PM and 8:00 AM Monday through Friday and between 4:00 PM and 9:00 AM on weekends and holidays is prohibited.	The proposed operations are exempt between the hours of 8 AM and 6 PM on weekdays and between 9 AM and 4 PM on weekends and holidays. Work outside of these times is prohibited.	http://www.amlegal.com/nxt/gateway.dll/California/fairfax_ca/townoffairfaxcaliforniamunicipalcodeofor?f=templates$fn=default.htm$3.0$vid=amlegal:fairfax_ca

Table 12-4 Marin and Sonoma County Summary of Local Noise Standards

Jurisdiction	Source	Standards	Applicability to Project	URL
Larkspur	Municipal Code Chapter 9.54.040, Noise Control Regulations	**9.54.060 Exemptions.** The following activities shall be exempted from the provisions of this chapter: D. Any mechanical device, apparatus or equipment related to or connected with emergency activities or emergency work. E. Noise sources associated with construction, repair, remodeling, demolition, or paving of any real property, provided said activities shall only occur during the following time periods: 1. Monday through Friday (excluding legal holidays) 7 AM to 6 PM Saturday, Sunday, and legal holidays 9 AM to 5 PM This exception is granted provided that all powered construction equipment is equipped with intake and exhaust mufflers recommended by the manufacturers thereof; pavement breakers and jackhammers shall also be equipped with acoustical attenuating shields or shrouds recommended by the manufacturers thereof. 2. In lieu of or in the absence of manufacturers' recommendations, the Director of Public Works shall have the authority to prescribe such means of accomplishing maximum noise attenuation as the director deems to be in the public interest, considering the available technology and economic feasibility. 3. The Director of Public Works may allow the following exception to the provisions of subsection (1) above: when an unforeseen or unavoidable condition occurs during a construction project and the nature of the project necessitates that work in progress be continued until a specific phase is completed, the contractor or owner may, with the consent of the Director of Public Works, be allowed to continue work after 6 PM and to operate machinery and equipment necessary to conclude the specific work in progress under conditions that will not jeopardize inspection acceptance or create undue financial hardships for the contractor or owner.	Ordinance provides work times, requirements for gasoline engine exhaust pipes and allows for exceptions by the Director of Public Works and/or by permit.	http://www.codepublishing.com/ca/Larkspur/html/Larkspur09/Larkspur0954.html
Mill Valley	Municipal Code, Title 7 Health and Sanitation, Chapter 7.16 Noise Control	**Construction Projects.** The noise levels produced by construction projects shall not exceed 60 dBA plus the adjustments of subsection B of Section 7.16.060 without issuance of a special permit. The special permit shall not be issued by the authorized City department unless the applicant demonstrates that the equipment to be used produces noise levels that are the lowest of currently available equipment. Exception: No permit is required to perform emergency work. Contractors shall be required to prominently display a notice of the date of commencement of construction noise at least three days prior to actual commencement. Such notice shall be located on the construction site and shall be readable from the closest adjacent street. **7.16.080 Exemptions** The following activities shall be exempted from the provisions of this chapter: C. Noise sources associated with or vibration created by construction, repair, remodeling, or grading of any real property or during authorized seismic surveys, provided such activities do not take place between the hours of 6:00 PM and 7:00 AM on weekdays, or at any time on Saturday, Sunday or a legal holiday, and provided the noise level created by such activities does not exceed the noise standard of 60 dBA plus the adjustments specified in subsection B of Section 7.16.060, as measured on residential property, and any vibration created does not endanger the public health, welfare and safety. Heavy equipment and power tools are restricted to weekdays between the hours of 8:00 AM and 5:00 PM Owner/occupant builders are exempt from the time and heavy equipment and power tools restrictions on Saturdays between the hours of 9:00 AM and 5:00 PM Construction noise sources exceeding the above limits shall be allowed only upon issuance of a special permit under subsection D of Section 7.16.090. Nothing in this chapter shall be construed to prohibit construction activities that do not exceed the Ambient noise level by more than 10 dBA, such as painting or interior work.	Requires special permits for non-emergency work. Construction type work is exempt between the hours listed in 7.16.080.	http://www.qcode.us/codes/millvalley/

Table 12-4 Marin and Sonoma County Summary of Local Noise Standards

<table>
<tr><th>Jurisdiction</th><th>Source</th><th>Standards</th><th>Applicability to Project</th><th>URL</th></tr>
<tr><td>Novato</td><td>Municipal Code 19.22.070</td><td>
Noise and Construction Hours
A. Applicability. Uses, activities, and processes shall not generate or emit any noise or sound in excess of the levels provided in Table 3-5 beyond the property line of the parcel on which they are located, except as provided in Subsection B.
B. Exceptions. The following are exempt from the allowable noise level requirements of Table 3-5 as noted:
2. Emergency vehicle responses and all necessary equipment utilized in responses to a declared state of emergency;
4. Authorized construction activities, including warming-up or servicing of equipment, and any preparation for construction between 7 AM and 6 PM on weekdays, and between 10 AM and 5 PM on Saturdays. No construction is allowed on Sundays or official federal national holidays, except as otherwise authorized herein by the Community Development Director.
5. Authorized grading activities and equipment operations between 7 AM to 6 PM weekdays only, when City inspectors are available.
6. Routine maintenance activities.
7. Other construction activities as authorized in writing by the Community Development Director.
C Noise Measurement. Exterior noise levels shall be measured at the property line of the noise source. Noise measurement shall be made with a sound level meter using the "A" weighted scale at slow meter response. Fast meter response shall be used only for an impulsive noise.

Table 3-5: Allowable Exterior Noise Levels
<table>
<tr><th rowspan="2">Type of Land Use</th><th colspan="2">Allowable Exterior Levels(1)</th></tr>
<tr><th>Time Interval</th><th>Maximum Noise Level(2)</th></tr>
<tr><td rowspan="2">Residential(3)</td><td>10 PM to 6 AM</td><td>45 dBA</td></tr>
<tr><td>6 AM to 10 PM</td><td>60 dBA</td></tr>
<tr><td rowspan="2">Commercial(4)</td><td>10 PM to 6 AM</td><td>60 dBA</td></tr>
<tr><td>6 AM to 10 PM</td><td>70 dBA</td></tr>
<tr><td>Industrial or manufacturing(4)</td><td>Any time</td><td>70 dBA</td></tr>
</table>
Notes:
(1) Each of the noise limits specified in Table 3-5 shall be reduced by 5 dBA for impulse or simple tone noises. If the Ambient noise exceeds the resulting standard, the Ambient shall be the standard.
(2) Maximum noise levels shall not be exceeded for an aggregate period of more than three minutes within a one-hour time period or by more than 20 dBA at any time.
(3) Residential standards apply to sensitive receptors such as schools, hospitals, libraries, group care facilities, and convalescent homes. These uses may require special mitigation.
(4) Commercial standards apply to Mixed Use Districts.
D. Authorized construction activity and uses established through the discretionary land use permit process may be subject to specific noise conditions of approval and/or mitigation measures that are more restrictive.
</td><td>Provides authorized construction activity hours and prohibitions as well as discretionary land use permits.</td><td>https://library.municode.com/index.aspx?clientId=16532</td></tr>
</table>

Table 12-4 Marin and Sonoma County Summary of Local Noise Standards

Jurisdiction	Source	Standards	Applicability to Project	URL
Ross	Municipal Code Chapter 9.20	The director of public works may, on a finding of good cause, grant written exceptions to these time limitations. Such permission must be obtained prior to the commencement of any work outside the prescribed hours. **9.20.035**. Construction. (a) It is unlawful for any person or construction company within the town limits to perform any construction operation before eight AM or after five PM, Monday through Friday of each week and not at any time on Saturday, Sunday, or the other holidays listed in Section 9.20.060 **9.20.070.** Exhaust pipe required for gasoline, etc., motor. No person having charge or control of any engine in which gas, gasoline, distillate or other similar substance is used as motive power, shall run or operate the engine, or cause it to be run or operated, without having the exhaust pipe thereof connected with an underground air chamber or having attached to the exhaust pipe a muffler or other device so constructed as to deaden the sound of the exhaust from making any loud noise or disturbing the peace and quiet of persons in its vicinity; provided, that this section shall not apply to motor vehicles, except when used in a stationary position for the purpose of supplying power other than for their own movement. (Ord. 267 §4(part), 1967: prior code §4352). **9.20.090.** Permit required when no other procedure is applicable. Unless other procedures are specifically provided in the particular sections of this chapter, a permit may be issued authorizing noises prohibited by this chapter whenever it is found the public interest will be served thereby. Applications for permits shall be in writing and shall be accompanied by an application fee in the amount of five dollars and shall set forth in detail the facts showing that the public interest will be served by the issuance of the permit. Applications shall be made to the building inspector; provided, however, with respect to work upon or involving the use of a public street, alley, building or other public place under the jurisdiction of the department of public works. No permits shall be issued unless the application is first approved by the department of public works, the chief of police and the town clerk. Anyone dissatisfied with the denial of a permit may appeal to the council. (Ord. 267 §4(part), 1967: prior code §4354).	Ordinance provides work times, requirements for gasoline engine exhaust pipes and allows for exceptions by the Director of Public Works and/or by permit.	http://www.townofross.org/pdf/resource_center/municipal_code/muni-code-complete-set.pdf
San Anselmo	Code of Ordinances, Title 4 – Public Welfare, Morals, and Conduct, Chapter 7	**Construction and demolition.** (a) Except as otherwise provided in subsections (b), (c), and (d) of this section, for a period of two (2) years after March 13, 1975, it shall be unlawful to operate any powered equipment if the operation of such equipment emits a noise level of eighty-five (85) dBA when measured at the loudest point fifty (50′) feet away from the equipment. On and after March 13, 1977, the permissible noise level shall be reduced to eighty (80) dBA. (b) Impact tools and equipment shall be excluded from the provisions of subsection (a) of this section; provided, however, on or after September 13, 1975, such impact tools and equipment shall have intake and exhaust mufflers recommended by the manufacturers thereof; and provided, further, pavement breakers and jackhammers shall also be equipped with acoustically attenuating shields or shrouds recommended by the manufacturers thereof. In lieu of or in the absence of manufacturers' recommendations, the Director of Public Works shall have the authority to prescribe such means of accomplishing maximum noise attenuation as he deems to be in the public interest, considering the available technology and economic feasibility. (c) Construction or demolition work may be performed during the following times: Mondays through Fridays from 7:00 AM to 7:00 PM; Saturdays from 9:00 AM to 5:00 PM; and Sundays from 12:00 PM to 5:00 PM; provided, however, such hours shall be extended until 8:00 PM for work performed by homeowners or residents upon their own property. Construction or demolition work shall be allowed at any time provided the noise level does not exceed five (5) dBA above the Ambient at the nearest property plane with allowance for correction factors as set forth in subsection (b) of Section 4-7.104 of Article I of this chapter. (d) The provisions of this section shall not apply to emergency work as defined in subsection (e) of Section 4-7.102 of Article 1 of this chapter. As defined in the above section, "emergency work" shall mean work made necessary to restore property to a safe condition following a public calamity or work required to protect persons or property from an imminent exposure to danger or work by private or public utilities when restoring utility service.	Provides authorized construction hours and noise level limits. Emergency work is exempt.	https://www.municode.com/library/ca/san_anselmo/codes/code_of_ordinances?nodeId=TIT4PUWEMOCO_CH7LONO_ART1GEPR

Table 12-4 Marin and Sonoma County Summary of Local Noise Standards

Jurisdiction	Source	Standards	Applicability to Project	URL
San Rafael	Code of Ordinances, Title 8, Chapter 8.13	**8.13.070 Exemptions.** The following shall be exempt from the provisions of this chapter: B. Emergency vehicle responses and all necessary equipment utilized for the purpose of responding to an emergency, or necessary to restore, preserve, protect or save lives or property from imminent danger of loss or harm; D. The operation of any municipal or public utility vehicles; F. Uses established through any applicable discretionary review process containing specific noise conditions of approval and/or mitigation measures; G. Work on capital improvements, or repairs on public property by employees or contractors of the city; H. Vehicle noise subject to regulation under the California Vehicle Code; I. Emergency repair work performed by, or at the request of, a property owner on his or her private property, where the delay required to obtain an exception permit under this chapter would result in substantial damage, personal injuries, or property loss to the owner, provided that such emergency work shall be subject to such reasonable conditions as may be imposed by authorized city employees to mitigate the noise level of the activity.	The proposed operations fall under one or more of the exemptions listed under 8.13.070.	https://www.municode.com/library/ca/san_rafael/codes/code_of_ordinances?nodeId=TIT8MOCO
Sausalito	Municipal code 12.16.040	**12.16.130 Machinery, equipment, fans and air conditioning** It is unlawful for any person to operate any machinery, equipment, pump, fan, air conditioning apparatus, or similar mechanical device in any manner so as to create any noise which would cause the noise level at the property line of any property to exceed the Ambient base noise level by more than five decibels. [Ord. 783 Art. II § 5, 1972.] **12.16.140 Time restrictions on operating construction devices in residential zones.** A. The operation of construction, demolition, excavation, alteration or repair devices and equipment shall only take place during the following hours: 1. Weekdays: Between 8:00 AM and 6:00 PM 2. Saturdays: Between 9:00 AM and 5:00 PM 3. Sundays: Prohibited. 4. Holidays officially recognized by the City of Sausalito not including Sundays: Between 9:00 AM and 7:00 PM	Provides noise level requirements relative to Ambient noise levels. Provides authorized construction activity hours and prohibitions.	http://www.codepublishing.com/ca/sausalito/
Tiburon	Title IV – Land Improvement and Use, Chapter 13 – Building Regulations. Article III. – Development Standards	**1313-6 Hours of Construction.** (a) Generally, all work covered by a permit issued under this chapter shall be performed only between the hours of seven AM to five PM, Monday through Friday, and nine thirty AM to four PM on Saturday. Only quiet work is allowed to be performed on Saturdays, such that noise from any source associated with the permitted work, including but not limited to construction activity, Amplified sound, and worker's voices, shall not be plainly audible beyond the property line. (b) Work covered by a permit shall not be performed on Sunday or on holidays observed by the Town of Tiburon. These holidays are New Year's Day, Martin Luther King Day, President's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day and Christmas Day. (c) For work covered by a permit, the arrival or departure of heavy equipment (including but not limited to concrete trucks, graders and backhoes) and/or the delivery of heavy items or materials (including but not limited to lumber, concrete, debris boxes, and portable restrooms) to a work site shall occur only on Monday through Friday between the hours of seven AM to five PM Hours of operation, maintenance, and servicing of heavy equipment shall be limited to eight AM to 5:00 PM, Monday through Friday. Heavy equipment may begin engine warm up, but not actual operation, at 7:30 AM (d) Exceptions. The limitations in sections 13-6(a) through (c) shall not apply in the following instances: (1) When prior to the commencement of any work covered by a permit issued under this chapter, the town manager grants written permission to perform work outside of the prescribed hours; (2) When work is necessary in an emergency situation to remedy or prevent damage to persons or property.	Provides authorized construction activity hours and prohibitions. Exceptions granted for emergencies.	https://library.municode.com/index.aspx?clientId=16657

Table 12-4 Marin and Sonoma County Summary of Local Noise Standards

<table>
<tr><th>Jurisdiction</th><th>Source</th><th>Standards</th><th>Applicability to Project</th><th>URL</th></tr>
<tr><td>Sonoma County</td><td>Sonoma County General Plan 2020, Noise Element</td><td>Policy NE-1c: Control non-transportation related noise from new projects. The total noise level resulting from new sources shall not exceed the standards in Table NE-2 as measured at the exterior property line of any adjacent noise sensitive land use. Limit exceptions to the following:
(1) If the Ambient noise level exceeds the standard in Table NE-2, adjust the standard to equal the Ambient level, up to a maximum of 5 dBA above the standard, provided that no measurable increase (i.e. +/- 1.5 dBA) shall be allowed.
(2) Reduce the applicable standards in Table NE-2 by 5 dBA for simple tone noises, noises consisting primarily of speech or music, or for recurring impulsive noises, such as pile drivers and dog barking at kennels.
(3) Reduce the applicable standards in Table NE-2 by 5 decibels if the proposed use exceeds the Ambient level by 10 or more decibels.
(4) For short-term noise sources which are permitted to operate no more than 6 days per year, such as concerts or race events, the allowable noise exposures shown in Table NE-2 may be increased by 5 dB. These events shall be subject to a noise management plan including provisions for maximum noise level limits, noise monitoring, complaint response and allowable hours of operation. The plan shall address potential cumulative noise impacts from all events in the area.
(5) Noise levels may be measured at the location of the outdoor activity area of the noise sensitive land use, instead of the exterior property line of the adjacent noise sensitive land use where:
(a) the property on which the noise sensitive use is located has already been substantially developed pursuant to its existing zoning, and
(b) there is available open land on those noise sensitive lands for noise attenuation.
This exception may not be used on vacant properties which are zoned to allow noise sensitive uses.
Table NE- 2 Maximum Allowable Exterior Noise Exposures for Non-transportation Noise Sources***
<table>
<tr><th>Hourly Noise Metric[1]
dBA</th><th>Daytime
(7 AM to 10 PM)</th><th>Nighttime
(10 PM to 7 AM)</th></tr>
<tr><td>L50 (30 minutes in any hour</td><td>50</td><td>45</td></tr>
<tr><td>L25 (15 minutes in any hour)</td><td>55</td><td>50</td></tr>
<tr><td>L08 (4 minutes 48 seconds in any hour)</td><td>60</td><td>55</td></tr>
<tr><td>L02 (72 seconds in any hour)</td><td>65</td><td>60</td></tr>
</table>
[1] The sound level exceeded n% of the time in any hour. For example, the L50 is the value exceeded 50% of the time or 30 minutes in any hour; this is the median noise level. The L02 is the sound level exceeded 1 minute in any hour.</td><td>The project includes short-term, non-transportation noise.</td><td>http://www.sonoma-county.org/prmd/gp2020/noise.pdf</td></tr>
<tr><td>City of Cloverdale</td><td>No applicable noise ordinance</td><td>NA</td><td>NA</td><td>http://www.cloverdale.net/DocumentCenter/Home/View/537</td></tr>
<tr><td>City of Cotati</td><td>Municipal Code 17.30.050</td><td>Table 3-5: Allowable Hours of Construction
<table>
<tr><th>Day</th><th>Allowable Hours</th></tr>
<tr><td>Monday through Friday</td><td>7:00 AM to 7:00 PM</td></tr>
<tr><td>Saturday and Sunday, Holidays</td><td>Construction activities may only be allowed by the review authority through conditions of approval between 9:00 AM and 5:00 PM</td></tr>
</table>
4. Limitation on Truck Deliveries. Truck deliveries to a commercial or industrial parcel adjacent to a residential zoning district shall be limited to the hours between seven AM and seven PM, unless the director authorizes other delivery times based on the determination that there is either no feasible alternative, or there are overriding transportation and traffic management benefits to scheduling deliveries at night.</td><td>Provides allowable hours of operation for construction-related activities.</td><td>http://www.codepublishing.com/CA/Cotati/</td></tr>
</table>

Table 12-4 Marin and Sonoma County Summary of Local Noise Standards

Jurisdiction	Source	Standards	Applicability to Project	URL
City of Healdsburg	Municipal Code 9.32.010	**Construction and Temporary Activities** A. Noise sources associated with or vibration created by construction, repair, remodeling, or grading of any real property or during authorized seismic surveys are permitted, provided such activities do not take place between the nighttime hours of 6:00 PM and 7:30 AM daily, or at any time on Sunday or a legal holiday, and provided the noise level created by such activities and any vibration created does not endanger the public health, welfare, and safety. C. Nothing in this section shall be construed to prohibit construction activities that do not exceed the Ambient noise level by more than 10 dBA, such as painting or interior work. (Ord. 1011 § 7, 2003.) **9.32.080 Standards for maximum sound levels and determining violations.** A. Sound Level Standards. It is the objective of the City to require intruding noise levels not to exceed those listed below to determine if a violation exists:	Provides allowable hours of operation. If Ambient noise levels are not exceeded by more than 10 dB(A), no prohibition exists.	http://www.codepublishing.com/CA/healdsburg/#!/Healdsburg09/Healdsburg0932.html
City of Petaluma	Municipal Code 21.020	Establishes prohibitions from construction work without permit though emergency **21.040.3 a**. The following specific acts, subject to the exemptions provided in Section 21.040(A)(5), are declared to be public nuisances and are prohibited: 1) The operation or use of any of the following before 7:00 AM or after 10:00 PM daily (except Saturday, Sunday and State, Federal or Local Holidays, when the prohibited time shall be before 9:00 AM and after 10:00 PM): 2) A hammer or any other device or implement used to repeatedly pound or strike an object. 3) An impact wrench, or other tool or equipment powered by compressed air. 4) Any tool or piece of equipment powered by an internal-combustion engine such as, but not limited to, chain saw, backpack blower, and lawn mower. Except as specifically included in this Ordinance, motor vehicles, powered by an internal combustion engine and subject to the State of California vehicle code, are excluded from this prohibition. 5) Any electrically or battery powered tool or piece of equipment used for cutting, drilling, or shaping wood, plastic, metal, or other materials or objects, such as but not limited to a saw, drill, lathe or router. 6) Any of the following: the operation and/or loading or unloading of heavy equipment (such as but not limited to bulldozer, road grader, back hoe), ground drilling and boring equipment, hydraulic crane and boom equipment, portable power generator or pump, pavement equipment (such as but not limited to pneumatic hammer, pavement breaker, tamper, compacting equipment), pile-driving equipment, vibrating roller, sand blaster, gunite machine, trencher, concrete truck, and hot kettle pump and the like. 7) Construction, demolition, excavation, erection, alteration or repair activity. **21.040.3 b**. In the case of urgent necessity and in the interest of public health and safety, the Noise Control Officer may issue a permit for exemption from the requirements with subsection 21.040(A)(3). Such period shall not exceed ten (10) working days in length but may be renewed for successive periods of thirty (30) days or less, not to exceed a total of 90 days while the emergency continues. Requests for exemptions beyond 90 days shall require public hearing approval. The Noise Control Officer may limit such permit as to time of use and/or permitted action, depending upon the nature of the emergency and the type of action requested. 6. Exceptions. a. Authorities. The Noise Control Officer is authorized to grant exceptions from any provision of this chapter, subject to limitations of proximity to noise sensitive uses, noise levels, time limits and other terms and conditions as the Noise Control Officer determines are appropriate to protect the public health, safety and welfare from the noise emanating therefrom. This section shall in no way affect the duty to obtain any permit or license required by law for such activities.	Provides allowable hours of operation and allows the Noise Control Officer to issue permits or grant exceptions.	http://cityofpetaluma.net/cdd/pdf/izo/chapter21-performance-standards.pdf
City of Rohnert Park	Title 9 – Public Peace, Morals and Welfare, Chapter 9.44 - Noise	Chapter 9.44 identifies Ambient base noise levels, noise standards for various sources, specific noise restrictions, exemptions, and variances for sources of noise within the city. The Noise Ordinance applies to all noise sources with the exception of any vehicle that is operated upon any public highway, street or right-of-way, or to the operation of any off-highway vehicle, to the extent that it is regulated in the State Vehicle Code, and all other sources of noise that are specifically exempted. The Noise Ordinance limits construction activity within a residential zone or a radius of 500 feet there from to the hours of 8:00 AM – 6:00 PM when the potential noise levels would cause discomfort or annoyance to a reasonable person of normal sensitiveness residing in the area. No permits are required to perform emergency work, which is defined as work made necessary to restore property to a safe condition following a public calamity or work required to protect persons or property from an imminent exposure to danger or work by private or public utilities when restoring utility service.	Acceptable hours of operation for construction activities are provided. Emergency work does not require a permit.	https://www.municode.com/library/#!/ca/rohnert_park/codes/code_of_ordinances?nodeId=TIT9PUPEMOWE_ARTIVOFAGPUPE_CH9.44NO

Table 12-4 Marin and Sonoma County Summary of Local Noise Standards

Jurisdiction	Source	Standards	Applicability to Project	URL
City of Santa Rosa	No applicable noise ordinance.	NA	NA	http://ci.sant-rosa.ca.us/departments/cityadmin/cityclerk/Pages/CityCode.aspx
City of Sebastopol	Municipal Code Title 8 Health and Safety, Chapter 8.25 Noise Ordinance	**8.25.060 NOISE LEVELS** 1. It shall be unlawful for any person to emit or cause to be emitted any noise beyond the boundaries of his/her premises in excess of the noise levels established in these regulations. 2. Noise level standards: A. No person in a residential zone shall emit noise beyond the boundaries of his/her premises exceeding the levels stated herein and applicable to adjacent residential, commercial and industrial zones. Noise Levels shall not exceed: Daytime Hours — 55 dBA Nighttime Hours — 45 dBA B. No person in a commercial zone shall emit noise beyond the boundary of his/her premises exceeding the levels state herein and applicable to adjacent residential, commercial or industrial zones: Noise Levels shall not exceed: Daytime Hours — 55 dBA Nighttime Hours — 45 dBA C. No person in an industrial zone shall emit noise beyond the boundary of his/her premises exceeding the levels stated herein and applicable to adjacent residential commercial or industrial zones: Noise Levels shall not exceed: Daytime Hours — 65 dBA Nighttime Hours — 55 dBA D. High background noise levels and impulse noise. In those individual cases where the background noise levels caused by sources not subject to these regulations exceed the standards contained herein, a source shall be considered to cause excessive noise if the noise emitted by such source exceeds the background noise levels by five (5) dBA, provided that no source subject to the provisions of this chapter shall emit noise in excess of eighty (80) dBA at any time and provided that this section does not decrease the permissible levels of other sections of this chapter. No person shall cause or allow the emission of impulse noise in excess of eighty (80) dB peak sound pressure level during the nighttime to any residential noise zone. No person shall cause or allow the emission of impulse noise in excess of one hundred (100) dB peak sound pressure level at any time to any zone. **F. Exemptions:** The following shall be exempt from these regulations subject to special conditions as spelled out: (1) Noise generated by any construction equipment which is operated during daytime hours, defined for the purposes of this section as from 7:00 AM to 8:00 PM, Monday through Friday, 8:00 AM to 5:00 PM on Saturdays and from 8:00 AM to 5:00 PM on Sundays. (2) Noise created as a result of or relating to an emergency. (3) Noise from demolition work conducted during daytime hours. When considered emergency work, demolition shall be exempted at all times from the noise levels set in this regulation. (6) Noise created by blasting other than that conducted in connection with construction activities shall be exempted, provided that the blasting is conducted between 8:00 AM and 5:00 PM local time at specified hours previously announced to the local public and provided that a permit for such blasting is obtained from the appropriate federal, state or local authorities. (9) Noise created by pick-up or delivery vehicles in commercial or industrial zones during daytime hours. "Daytime hours, defined for the purposes of this section as from 7:00 AM to 8:00 PM, Monday through Friday, 8:00 AM to 5:00 PM on Saturdays and from 8:00 AM to 5:00 PM on Sundays.	Provides allowable hours for construction activities.	http://ci.sebastopol.ca.us/sites/default/files/mgourley/updated_december_2014_municipal_code_2013_entire_code.pages_.pdf

Table 12-4 Marin and Sonoma County Summary of Local Noise Standards

Jurisdiction	Source	Standards	Applicability to Project	URL
City of Sonoma	Sonoma Municipal Code, Title 9 Public Peace, Safety and Morals, Chapter 9.56 Noise	**9.56.050 Standard Exceptions to General Noise Limits**. The following standard exceptions to the provisions of SMC 9.56.040 shall be allowed as of right, to the extent and during the hours specified. A summary of the standard exceptions provided in this section is set forth in Table 2. A. Construction. Except as otherwise provided in subsection (B) of this section, or by the planning commission or city council as part of the development review for the project, on any construction project on property within the city, construction, alteration, demolition, maintenance of construction equipment, deliveries of materials or equipment, or repair activities otherwise allowed under applicable law shall be allowed as follows: (1) between 8:00 AM and 6:00 PM, Monday through Friday, (2) between 9:00 AM and 6:00 PM on Saturday, and (3) between 10:00 AM and 6:00 PM on Sundays and holidays; however, the noise level at any point outside of the property plane of the project shall not exceed 90 dBA.	Provides acceptable hours of operation for construction, alteration, demolition, maintenance of construction equipment, deliveries of material or equipment and/or repair activities.	http://codepublishing.com/ca/sonoma/frameless/index.pl?path=../html/Sonoma09/Sonoma0956.html#9.56.050
Town of Windsor	No applicable noise ordinance.	NA	NA	http://www.ci.windsor.ca.us/DocumentCenter/Home/View/3193

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Other CEQA Guidelines Appendix G criteria for noise impacts include impacts from permanent increases in noise levels, ground-borne vibration, and impacts from nearby airports and airstrips. With regard to vibration, Program equipment with the highest vibratory potential would include light trucks. While these vehicles may produce vibration, the levels would not be expected to be perceptible over existing vibration from delivery or highway truck traffic, and vibration levels would not reach thresholds for human annoyance or structural damage. With regard to permanent increases in noise levels, noise from the Program would be temporary and would last only for the duration of each activity. No potential exists to produce permanent increases in noise as a result of the Program. Finally, with regard to airports and airstrips, the Program would not result in the location of any new receptors near airports or airstrips. Therefore, these three criteria have been dismissed from the analysis and are not discussed further.

Concerns raised during scoping include:

> Noise-related impacts on humans, in particular consistency with local noise regulations

> Noise-related impacts on wildlife

The potential to exceed noise standards and result in substantial temporary noise levels above those existing (and without the Program equipment in use) within the Program Area are evaluated for each Program alternative. Impacts of Program noise on wildlife are addressed in Chapter 5, *Biological Resources-Terrestrial*.

12.2.2 Evaluation Methods and Assumptions

The methodology and assumptions of this noise impact evaluation for Program alternatives are provided below.

12.2.2.1 Methodology

The methodology used to prepare this programmatic noise impact section is as follows:

> Reviewed transcripts from public scoping meetings on the PEIR held in June 2012.

> Reviewed federal, state, and county and municipal noise regulations, plans, ordinances, and/or guidelines for general noise issues and issues related to Program-specific noise sources.

> Obtained source-specific noise data for Program-specific noise sources where available.

> Estimated noise levels for specific and categorical equipment types proposed for Program operations where specific noise data were not available at 50 feet and 400 feet from point of measure.

> Compared Proposed Program activities with those that currently occur under the existing vector control program (existing conditions).

> Determined probable noise impacts associated with the alternatives proposed in Chapter 2 based on the above significance thresholds. The impact analysis is based on detailed information regarding equipment and vehicle types and usage, and land uses where they would be used provided by each of the Districts. Detailed information regarding the noise generated by each type of equipment and vehicles that would be used is shown in Appendix D, Table 4-4.

12.2.2.2 Assumptions

The following assumptions were used in the assessment of potential noise impacts from the Program alternatives:

> Impacts are addressed at a programmatic level based on categories of land use types. Site-specific evaluation of noise sources and potential impacts is beyond the scope of this programmatic evaluation.

Also, the District has committed to implementation of BMPs to avoid and minimize impacts from their Program activities. The analysis of impacts considered the implementation of the following BMPs (from

Section 2.9, Table 2-6) that the District uses for operations that generate noise expected to be of concern to the public:

> Vehicles driving on levees to travel through tidal marsh or to access sloughs or channels for surveillance or treatment activities will travel at speeds no greater than 10 miles per hour to minimize noise and dust disturbance. (BMP A8)

> Operation of noise-generating equipment (e.g., chainsaws, wood chippers, brush-cutters, pickup trucks) will abide by the time-of-day restrictions established by the applicable local jurisdiction (i.e., City and/or County) if such noise activities would be audible to receptors (e.g., residential land uses, schools, hospitals, places of worship) located in the applicable local jurisdiction. Shut down all motorized equipment when not in use. (BMP A11)

> For operations that generate noise expected to be of concern to the public, the following measures will be implemented:

  - Measure 1: Provide Advance Notices. A variety of measures are implemented depending on the nature/magnitude of the activities, including press releases, social media, District websites, hand-delivered flyers, posted signs, emails, and/or phone alerts. Public agencies and elected officials also may be notified of the nature and duration of the activities, including the local Board of Supervisors or City Council, environmental health and agricultural agencies, emergency service providers, and airports. (BMP A12)

  - Measure 2: Provide Mechanism to Address Complaints. The District staff is available during regular business hours to respond to service calls and address concerns about nighttime operations. (BMP A12)

> Engine idling times will be minimized either by shutting equipment and vehicles off when not in use or reducing the maximum idling time to 5 minutes. Correct tire inflation will be maintained in accordance with manufacturer‘s specifications on wheeled equipment and vehicles to prevent excessive rolling resistance. All equipment and vehicles will be maintained and properly tuned in accordance with manufacturer‘s specifications. All equipment will be checked by a certified visible emissions evaluator if visible emissions are apparent to onsite staff. (BMP A14)

> The District will provide notification to the public (24 to 48 hours in advance if possible) and/or appropriate agency(ies) when applying pesticides or herbicides for large-scale treatments (e.g., fixed wing aircraft or helicopters) that will occur in close proximity to homes, heavily populated, high traffic, and sensitive areas. The District infrequently applies or participates in the application of herbicides in areas other than District facilities. (BMP H13)

12.2.3 Surveillance Alternative

The Surveillance Alternative would involve both ground surveillance and water surveillance. As shown in Table 12-5, ground surveillance would require the periodic use of light trucks, such as pickup trucks and jeeps, and ATVs and would take place in all land use types. Water surveillance would require the use of ATVs and, occasionally, boats and most frequently would occur in agricultural and open-space areas including wildlife refuges, where noise-sensitive human receptors are typically not located. Table 12-5 also shows the range of noise levels that vehicles and equipment typically would generate at 50- and 400-foot distances from the source. As indicated, noise attenuates, or is reduced, rapidly as the distance from the noise source increases. Detailed information regarding the average number of hours per day and the number of days in a quarter that equipment and vehicles would be used is included in Appendix D. Most equipment would only be operated a few hours per day for varying periods of time throughout the year.

Table 12-5 Surveillance Alternative – Primary Equipment Use, Noise Levels, and Land Use Types

Activity	Application Equipment	Predicted Noise Level (dBA)		Land Use Types				
		50 feet	400 feet	Residential	Commercial	Industrial	Agricultural	Open Space
Ground Surveillance & Application/Mgt	Light trucks	83	65	●	●	●	●	●
	ATVs	87	69				●	●
Water Surveillance & Applications/Mgt	Airboat, other boats	75-95	57-77				●	●

12.2.3.1 Exceedance of Noise Standards

The District BMPs include requiring operation of noise-generating equipment to abide by the time-of-day restrictions established by the applicable local jurisdiction if such noise activities would be audible to receptors located in the applicable local jurisdiction; thus, this alternative would be consistent with the time-of-day standards established by each of the local jurisdictions.

Most jurisdictions identify noise limits allowed during certain times of day as a result of construction activities. As noted above, the BMPs include requiring operation of noise-generating equipment to abide by the time-of-day restrictions established by the applicable local jurisdiction if such noise activities would be audible to receptors located in the applicable local jurisdiction. Noise from this alternative would be periodic, limited to brief periods of time spread out over multiple days in multiple locations, minimizing the amount of time any sensitive receptor was exposed to increased noise. The only land-based equipment operated near residential and commercial development would be light trucks, which are commonly used in such areas and would not increase noise levels beyond the established thresholds given that only a few trucks would be used and they would be in proximity to such uses only for a brief period of time.

ATVs primarily would be used in agricultural and open-space areas, as well as industrial areas, which are typically not considered to be noise-sensitive receptors. No thresholds for agricultural and open-space land uses have been established by local jurisdictions, and the guidelines USEPA and State of California established are intended to protect human receptors in such areas from long-term sources of noise, not temporary, sporadic sources such as would occur under the Program. Boats would be used in open-space areas. Airboats would be used primarily in areas such as marshes and seasonal wetlands. Given the temporary, sporadic increase in noise at any given location, noise from the Surveillance Alternative would not exceed regulatory standards.

> **Impact N-1:** Use of equipment and vehicles under the Surveillance Alternative would increase noise levels during operations, but this increase would not exceed noise standards. This impact is **less than significant** based on the frequency and duration of the activity, resulting noise levels, and compliance with BMPs. No mitigation is required.

12.2.3.2 Substantial Temporary Increase in Noise Levels

Noise from the use of light trucks generally would not be distinguishable from ambient noise levels because it takes a doubling of traffic to increase noise levels by only 3 dB. The types of light trucks that would be used (e.g., pickup trucks and jeeps) are common, and a limited number of vehicles would be used and would be dispersed over a large area. Use of ATVs and boats would occur in agricultural and

open-space areas; they generally would not be used in proximity to noise-sensitive receptors, although certain types of open-space areas may have increased sensitivity to noise, such as those used by recreational users seeking quiet, and some boats could be used within approximately 100 yards of residential areas. Given the limited numbers of vehicles and boats that would be used sporadically for brief periods of time over a large area and the limited duration that they would be used in any given location, noise levels would not increase by 3- to 5-dBA CNEL in proximity to noise-sensitive receptors. The District also is already implementing the types of activities that are part of this alternative; thus, this alternative represents a continuation of existing conditions, and noise levels from Program activities would not increase beyond those that already occur. In addition, BMP A8 requires reduced vehicle speed on levees, reducing noise levels in these areas. Furthermore, BMP 14 requires that all equipment and vehicles will be maintained and properly tuned in accordance with the manufacturer's specifications, not only improving air quality but reducing noise as well. In addition, BMPs A11 and A12-will be implemented as appropriate by providing advance notification of noise-generating activities expected to be of concern to the public and providing a means for registering public complaints about noise, thus further minimizing the potential for public annoyance.

> **Impact N-2:** Use of equipment and vehicles under the Surveillance Alternative would cause a temporary increase in noise levels during operations. This increase would not be substantial and, therefore, is **less than significant** based on the frequency and duration of the activity, resulting noise levels, comparability to noise resulting from existing activities, and implementation of BMPs. No mitigation is required.

12.2.4 Physical Control Alternative

The Physical Control Alternative involves a variety of actions, some of which would not directly result in noise; they include educating and advising landowners regarding appropriate methods to manage vectors such as rats and mosquitoes. Other activities would require the implementation of maintenance activities within marshes and wetlands, which typically are in undeveloped areas and not in proximity to noise-sensitive receptors. Other activities would take place in more urban areas, such as those including localized vegetation/water circulation management associated with wastewater treatment facilities.

As shown in Table 12-6, ground management would require the periodic use of light trucks, such as pickup trucks and jeeps, and ATVs, as well as equipment such as mowers, excavators, weed-eaters, and chainsaws. Hedge trimmers are relatively quiet so not included in the table (i.e., not an issue). Water management would require the use of ATVs and, occasionally, boats. Table 12-6 also shows the range of noise levels that they typically would generate at 50- and 400-foot distances from the source. This table also shows the land use types where activities typically would occur.

Table 12-6 Physical Control Alternative–Primary Equipment Use, Noise Levels, and Land Use Types

Activity	Application Equipment	Predicted Noise Level (dBA)		Land Use Types				
		50 feet	400 feet	Residential	Commercial	Industrial	Agricultural	Open Space
Ground Surveillance & Application/Mgt	Light trucks	**83**	**65**	●	●	●	●	●
	Mowers	80	58	●	●	●		
	Excavators	87	69	●	●	●	●	●
	Weed-eater, chainsaw	67-72	49-54	●	●	●	●	●
Water Surveillance & Applications/Mgt	Airboat, other boats	75-95	57-77				●	●
	ATVs	87	69				●	●

12.2.4.1 Exceedance of Noise Standards

The discussion under the Surveillance Alternative related to the use of light trucks, boats/airboats, and ATVs is applicable to the Physical Control Alternative because similar types of vehicles and equipment would be used, and they would generate similar amounts of noise and be used for a similar length of time. This alternative also would require the periodic use of other equipment, which would generate noise that was less than or equal noise from trucks, airboats, and ATVs. Noise generated by the Physical Control Alternative would not exceed noise standards due to the sporadic, temporary nature of the impact.

> **Impact N-3:** Use of equipment and vehicles under the Physical Control Alternative would increase noise levels during operations, but this increase would not exceed regulatory thresholds. This impact is **less than significant** based on the frequency and duration of the activity and resulting noise levels. No mitigation is required.

12.2.4.2 Substantial Temporary Increase in Noise Levels

The discussion under the Surveillance Alternative related to the use of light trucks and ATVs is applicable to the Physical Control Alternative because similar types of vehicles and equipment would be used, and they would generate similar amounts of noise and be used for a similar length of time. The District is already implementing the types of activities that would occur under this alternative and noise impacts, therefore, would be comparable to those that already occur. In addition, BMPs will be implemented as appropriate by providing advance notification of noise-generating activities expected to be of concern to the public based on the District's knowledge of the area it serves and any complaints or concerns received. The District has received few complaints about noise from control activities. BMP 12 provides a means for registering public complaints about noise, thus further minimizing the potential for public annoyance.

> **Impact N-4:** Use of equipment and vehicles under the Physical Control Alternative would cause a temporary increase in noise levels during operations. This increase would not be substantial, and therefore is **less than significant** based on the frequency and duration of the activity, resulting noise levels, comparability to noise resulting from existing activities, and implementation of BMPs. No mitigation is required.

12.2.5 Vegetation Management Alternative

Certain elements of the Vegetation Management Alternative would not directly generate noise, such as providing suggestions to landowners on how to perform vegetation management on their property. At other times, District staff periodically would undertake vegetation management activities, which require the use of hand tools or other mechanical means (i.e., heavy equipment) for vegetation removal, thinning, or trimming and sometimes may apply herbicides (chemical pesticides with specific toxicity to plants) to improve surveillance or reduce vector habitats. Vegetation removal, thinning, or trimming primarily occurs in aquatic habitats to assist with access, surveillance, and the control of mosquitoes and in terrestrial habitats to help with the control of other vectors. To reduce the potential for mosquito breeding associated with water retention and infiltration structures, District staff may systematically clear weeds and other obstructing vegetation in wetlands and retention basins. Alternatively, the District may request the structures' owners to perform this task. In this case, it will be the responsibility of the landowner to determine and comply with all legal requirements necessary to perform the activity. District policy is that with every recommendation, the District also makes it clear to the landowner the requirement for consultation with resource agencies and acquisition of permits that may be needed prior to commencement of any work. Tools ranging from shovels and pruners to chainsaws and weed-eaters up to heavy equipment can all be used at times to clear plant matter that either prevents access to mosquito breeding sites or that fosters good water management practices that would minimize mosquito populations. Generally, however, District "brushing" activities rely almost entirely on hand tools.

As shown in Table 12-7, vegetation management would require the periodic use of light trucks, such as pickup trucks and jeeps, and ATVs, as well as equipment such as tractors, mowers, chainsaws, weed-eaters, and sprayers. Water management would require the use of ATVs and, occasionally, boats. In addition to the vehicles and equipment that the District would use, Table 12-7 shows the range of noise levels that they typically would generate at 50- and 400-foot distances from the source and the land uses that typically would be affected. Shovels and other hand tools that generate no noise or minimal noise are not included in this table.

Table 12-7 Vegetation Management Alternative – Primary Equipment Use, Noise Levels, and Land Use Types

Activity	Application Equipment	Predicted Noise Level (dBA)		Land Use Types				
		50 feet	400 feet	Residential	Commercial	Industrial	Agricultural	Open Space
Ground Surveillance & Application/Mgt	Light trucks	83	65	●	●	●	●	●
	ATVs	87	69				●	●
	Tractor, mower	76	58				●	●
	Weed-eater, chainsaw	67-72	49-54	●	●	●	●	●
	Sprayer	65	47	●	●	●	●	●
Water Surveillance & Applications/ Management	Airboat, other boats	75-95	57-77				●	●

12.2.5.1 Exceedance of Noise Standards

The discussion under the Surveillance Alternative related to the use of light trucks and ATVs and airboats and other boats is applicable to the Vegetation Management Alternative because similar types of vehicles would be used, and they would have comparable noise levels and also would be used for brief periods of time over multiple locations. The Vegetation Management Alternative also would require the use of equipment such as tractors, mowers, weed-eaters, chainsaws, and sprayers, but such equipment would primarily be used in agricultural and open-space areas, which are not considered noise-sensitive receptors. Noise generated would be similar to that which already occurs and would not exceed noise standards.

> **Impact N-5:** Use of equipment and vehicles under the Vegetation Management Alternative would increase noise levels during operations, but this increase would not exceed regulatory thresholds. This impact is **less than significant** based on the frequency and duration of the activity and resulting noise levels. No mitigation is required.

12.2.5.2 Substantial Temporary Increase in Noise Levels

The discussion under the Surveillance Alternative related to the use of light trucks and ATVs, airboats, and other boats is applicable to the Vegetation Management Alternative because similar types of vehicles would be used, they would have comparable noise, levels, and they also would be used for brief periods of time over multiple locations. Noise generated would be similar to that which already occurs and would not result in a substantial temporary increase in noise levels. The Vegetation Management Alternative also would require the use of equipment such as tractors, mower, weed-eaters, chainsaws, and sprayers, but such equipment would primarily be used in agricultural and open-space areas, which are not considered noise-sensitive receptors. In addition, BMPs will be implemented as appropriate by providing advance notification of noise-generating activities expected to be of concern to the public (e.g., recreationists potentially present in open-space areas) and providing a means for registering public complaints about noise, thus further minimizing the potential for public annoyance.

> **Impact N-6:** Use of equipment and vehicles under the Vegetation Management Alternative would cause a temporary increase in noise levels during operations. This increase would not be substantial, and therefore is **less than significant** based on the frequency and duration of the activity, resulting noise levels, comparability to noise resulting from existing activities, and implementation of BMPs. No mitigation is required.

12.2.6 Biological Control Alternative

The Biological Control Alternative involves the use of mosquito pathogens, parasites, and predators (i.e., mosquitofish). The parasites are not commercially available at present. The other options would generate noise, from the periodic use of light trucks (for distribution of mosquitofish at artificial waterbodies only), and occasionally, ATVs, boats, tractors, and sprayers for the pathogens which are discussed under the Chemical Control Alternative. Examples of bacteria pathogenic to mosquitoes are Bs, the several strains of Bti, and *Saacharopolyspora spinosa* (or spinosad). The focus in this section is on the use of mosquitofish.

The number and type of vehicles and equipment required, as shown in Table 12-8, which also shows the range of noise levels that they typically would generate at 50- and 400-foot distances from the source and the land uses that would be affected.

Table 12-8 Biological Control – Primary Equipment Use, Noise Levels, and Land Use Types

Activity	Application Equipment	Predicted Noise Level (dBA)[a]			Land Use Types				
		50 feet	400 feet	500 feet	Residential	Commercial	Industrial	Agricultural	Open Space
Ground Surveillance & Application/Mgt	Light trucks	83	65	—	•	•	•	•	•

12.2.6.1 Exceedance of Noise Standards

The discussion under the Surveillance Alternative related to the use of light trucks is applicable to the Biological Control Alternative because similar types of vehicles would be used, with similar noise levels, and they also would be used for brief periods of time over multiple locations. Trucks would be used for limited periods of time at any given location, within the hours allowed by the local jurisdictions, as required by the BMPs and, thus, would not exceed noise standards.

> **Impact N-7:** Use of vehicles under the Biological Control Alternative would increase noise levels during operations, but this increase would not exceed regulatory thresholds. This impact is **less than significant** based on the frequency and duration of the activity and resulting noise levels. No mitigation is required.

12.2.6.2 Substantial Temporary Increase in Noise Levels

The discussion under the Surveillance Alternative related to the use of light trucks is applicable to the Biological Control Alternative because similar types of vehicles would be used, they would have similar noise levels, and they also would be used for brief periods of time over multiple locations.

> **Impact N-8:** Use of vehicles under the Biological Control Alternative would cause a temporary increase in noise levels during operations. This increase would not be substantial and, therefore, is **less than significant** based on the frequency and duration of the activity and resulting noise levels, and implementation of BMPs. No mitigation is required.

12.2.7 Chemical Control Alternative

A variety of activities would be implemented under the Chemical Control Alternative. Some activities for mosquito larviciding and adulticiding would require extensive use of vehicles and equipment. Noise associated with applications of biological pathogens as larvicides is discussed here.

The District would use a variety of techniques and equipment to apply mosquito larvicides, including handheld sprayers, backpack sprayers and blowers, truck- or ATV-mounted spray rigs, and helicopters or other aircraft. The Districts use conventional pickup trucks, ATVs, and boats as larvicide vehicles. Equipment used in ground applications of liquid formulations include handheld sprayers (handcans or spray bottles), and backpack sprayers and blowers. Handheld sprayers (handcans) are standard 1- or 2- or 3-gallon garden style pump-up sprayers used to treat very small isolated areas. Backpack sprayers are either hand pump-up for liquid applications and have a 2.5/3 to 5-gallon tank or are gas powered. When large areas are simultaneously producing mosquito larvae at densities exceeding District treatment thresholds, then the District may use helicopters or other aircraft to apply larvicides. Aerial application by helicopter of larvicides is a relatively infrequent activity for the District, and makes up only a small portion of the District's larvicide applications each year, with each application covering from approximately 20 to

600 acres, the smaller acreage sites are typically problematic and contain dense and abundant vegetation). Aerial application of liquid larvicides typically occurs during daylight hours and at an altitude above the treatment site of approximately 50 feet or less. Granular applications would occur during daylight hours at a 50-foot altitude or less.

The most common form of adulticide application is via the use of Ultra Low Volume (ULV) methods and equipment mounted on trucks, ATVs, golf carts, and watercraft or handheld for ground applications, applying the materials at very low dosage rates.

Aerial applications of mosquito larvicides and adulticides using helicopters and, potentially, fixed-wing aircraft in the future are used to obtain effective control in expansive areas or areas in which access is especially difficult and/or impediments to applying larvicides (and adulticides) from the ground exist, such as a dense canopy cover of invasive vegetation. The flight parameters differ by program and technique. Some operators apply adulticides by flying during hours of daylight, so their applications begin either at morning's first light or before sunset and work into twilight. The aircraft can be flown at a less than 200-foot altitude, which may make it easier to hit the target area. Other operations may be conducted in the dark of the night, typically after twilight or early in the morning before dawn. The aircraft typically are flown between 200- and 300-foot altitudes. Swath widths vary from operation to operation but are normally set somewhere between 400 and -1,200 feet. Aerial applications of larvicides (but also adulticides if a very large area requires treatment) may be conducted over, but are not limited to, the following land uses within the Program Area: salt marsh, diked marsh, seasonal wetlands; evaporation ponds and wastewater ponds; and agricultural, residential, commercial, industrial, and recreational areas. Urban or suburban areas would only be treated with adulticides in the event of a severe risk of disease transmission.

The type of vehicles and equipment required, as shown in Table 12-9, which also shows the range of noise levels that they typically would generate at 50- and 400-foot distances from the source and the land uses that would be affected. Noise from helicopters also is shown at a 500-foot distance. All land use types potentially could be treated through aerial applications.

Table 12-9 Chemical Control Alternative – Primary Equipment Use, Noise Levels, and Land Use Types

Activity	Application Equipment	Predicted Noise Level (dBA)[a]			Land Use Types				
		50 feet	400 feet	500 feet	Residential	Commercial	Industrial	Agricultural	Open Space
Ground Surveillance & Application/Mgt	Light trucks, water truck	75-88	57-70	—	●	●	●	●	●
	ATVs	87	69					●	●
	Foggers	50-75	32-57		●	●	●	●	●
	Sprayers	65-75	47-57		●	●	●	●	●
Water Surveillance & Applications/Mgt	Airboat, other boats	75-95	57-77	—				●	●
	Sprayers	65	47					●	●
Aerial Applications	Helicopter, fixed-wing aircraft			84-89	●	●	●	●	●

Notes:

[a] Noise from aircraft used for agricultural operations, such as those expected to be used for aerial applications, is not regulated by the FAA and, therefore, no noise information is available. Noise likely would be comparable to that of helicopters.

12.2.7.1 Exceedance of Noise Standards

The discussion under the Surveillance Alternative related to the use of light trucks and ATVs, airboats, other boats, and sprayers is applicable to the Chemical Control Alternative because similar types of vehicles and equipment would be used, they would have comparable noise levels, and they also would be used for brief periods of time over multiple locations. The use of foggers would generate less noise than sprayers. Their use would result in a temporary noise increase at any given location, which would not exceed noise standards. Helicopters or fixed-wing aircraft would be used under this alternative; however, they would be used only briefly in any given area and generally would operate in open-space or agricultural areas, although other land use types could be affected as well. The brief increase in noise from the periodic use of helicopters and fixed-wing aircraft and other vehicles and equipment would not exceed noise standards.

> **Impact N-9:** Use of equipment and vehicles under the Chemical Control Alternative would increase noise levels during operations, but this increase would not exceed regulatory thresholds. This impact is **less than significant** based on the frequency and duration of the activity and resulting noise levels. No mitigation is required.
>
> **Impact N-10:** Helicopter/aircraft/airboat use under the Chemical Control Alternative would temporarily increase noise levels during operations, but would not exceed regulatory thresholds. This impact is **less than significant** based on the frequency and duration of the activity and resulting noise levels. No mitigation is required.

12.2.7.2 Substantial Temporary Increase in Noise Levels

The discussion under the Surveillance Alternative related to the use of light trucks and ATVs, airboats, other boats, and sprayers is applicable to the Chemical Control Alternative because similar types of vehicles and equipment would be used, they would have similar noise levels, and they also would be used for brief periods of time over multiple locations. Foggers would generate less noise than sprayers; thus, their periodic use would not result in a substantial increase in noise levels. As discussed in the preceding section, helicopters/fixed-wing aircraft also would be used, but only for brief periods up to several times a year, and they would affect any given area only briefly. Noise from helicopter/aircraft use immediately after twilight would not be expected to result in sleep disturbance. While noise from helicopters/aircraft operating during nighttime hours could result in sleep disturbance for those in the immediate vicinity, most of this activity would take place over open-space areas that are not populated. Although some of the helicopters/aircraft could operate over all land -use types, the impacts on any one location would be minimized because they would move continuously to new areas. In addition, BMPs will be implemented as appropriate by providing advance notification of noise-generating activities expected to be of concern to the public and providing a means for registering public complaints about noise, thus further minimizing the potential for public annoyance.

> **Impact N-11:** Use of equipment and vehicles under the Chemical Control Alternative would cause a temporary increase in noise levels during operations. This increase would not be substantial and, therefore, is **less than significant** based on the frequency and duration of the activity, resulting noise levels, comparability to noise resulting from existing activities, and implementation of BMPs. No mitigation is required.
>
> **Impact N-12:** Helicopter/aircraft/airboat use under the Chemical Control Alternative would temporarily increase noise levels during operations, but this increase would not be substantial. This impact is **less than significant** based on the frequency and duration of the activity, resulting noise levels, and implementation of BMPs. No mitigation is required.

12.2.8 Other Nonchemical Control/Trapping Alternative

This alternative primarily includes the trapping of rodents and/or yellow jackets that pose a threat to public health and welfare; light trucks would be used to access sites. Table 12-10 shows the range of noise levels that light trucks typically would generate at a 50-foot distances from the source and the land uses that would be affected.

Table 12-10 Other Nonchemical Control/Trapping Alternative – Primary Equipment Use, Noise Levels, and Land Use Types

Activity	Application Equipment	Predicted Noise Level (dBA)		Land Uses Types				
		50 feet	400 feet	Residential	Commercial	Industrial	Agricultural	Open Space
Ground Surveillance & Application/Mgt	Light trucks	83	65	●	●	●	●	●

12.2.8.1 Exceedance of Noise Standards

The only land-based equipment operated near residential and commercial development would be light trucks, which are commonly used in such areas and would not increase noise levels beyond the established thresholds given that only a few trucks would be used and they would be in proximity to such uses only for a brief period of time. Noise generated would be similar to that which already occurs and would not exceed noise standards.

> **Impact N-13:** Use of equipment and vehicles under the Other Nonchemical Control/Trapping Alternative would increase noise levels during operations, but this increase would not exceed regulatory thresholds. This impact is **less than significant** based on the frequency and duration of the activity and resulting noise levels. No mitigation is required.

12.2.8.2 Substantial Temporary Increase in Noise Levels

Noise from the use of light trucks generally would not be distinguishable from ambient noise levels because it takes a doubling of traffic to increase noise levels by only 3 dB. The types of light trucks that would be used (e.g., pickup trucks and jeeps) are common, and a limited number of vehicles would be used and would be dispersed over a large area. Thus, their use would not result in a substantial temporary increase in noise levels.

> **Impact N-14:** Use of equipment and vehicles under the Other Nonchemical Control/Trapping Alternative would cause a temporary increase in noise levels during operations. This increase would not be substantial and, therefore, is **less than significant** based on the frequency and duration of the activity, resulting noise levels, comparability to noise resulting from existing activities, and implementation of BMPs. No mitigation is required.

12.2.9 Cumulative Impacts

Cumulative noise impacts are discussed in Section 13.10. In summary, the potential for cumulative impacts is low, and any impacts that did occur would be of short duration and less than significant. **The incremental noise impacts from any of the Program alternatives, individually or in combination for the entire Program, would not be cumulatively considerable and would not trigger cumulative noise impacts in a given area**.

12.2.10 Environmental Impacts Summary

Table 12-11 is a summary of all of the potential noise impacts associated with the Program alternatives in comparison to existing conditions. The number of each statement correlates to its number in the text.

Table 12-11 Summary of Noise Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Effects on Noise						
Impact N-1: Use of equipment and vehicles under the Surveillance Alternative would increase noise levels during operations, but this increase would not exceed noise standards. This impact is **less than significant** based on the frequency and duration of the activity, resulting noise levels, and compliance with BMPs. No mitigation is required.	LS	na	na	na	na	na
Impact N-2: Use of equipment and vehicles under the Surveillance Alternative would cause a temporary increase in noise levels during operations. This increase would not be substantial and, therefore, is **less than significant** based on the frequency and duration of the activity, resulting noise levels, comparability to noise resulting from existing activities, and implementation of BMPs. No mitigation is required.	LS	na	na	na	na	na
Impact N-3: Use of equipment and vehicles under the Physical Control Alternative would increase noise levels during operations, but this increase would not exceed regulatory thresholds. This impact is **less than significant** based on the frequency and duration of the activity and resulting noise levels. No mitigation is required.	na	LS	na	na	na	na
Impact N-4: Use of equipment and vehicles under the Physical Control Alternative would cause a temporary increase in noise levels during operations. This increase would not be substantial, and therefore is **less than significant** based on the frequency and duration of the activity, resulting noise levels, comparability to noise resulting from existing activities, and implementation of BMPs. No mitigation is required.	na	LS	na	na	na	na

Table 12-11 Summary of Noise Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact N-5: Use of equipment and vehicles under the Vegetation Management Alternative would increase noise levels during operations, but this increase would not exceed regulatory thresholds. This impact is **less than significant** based on the frequency and duration of the activity and resulting noise levels. No mitigation is required.	na	na	LS	na	na	na
Impact N-6: Use of equipment and vehicles under the Vegetation Management Alternative would cause a temporary increase in noise levels during operations. This increase would not be substantial, and therefore is **less than significant** based on the frequency and duration of the activity, resulting noise levels, comparability to noise resulting from existing activities, and implementation of BMPs. No mitigation is required.	na	na	LS	na	na	na
Impact N-7: Use of vehicles under the Biological Control Alternative would increase noise levels during operations, but this increase would not exceed regulatory thresholds. This impact is **less than significant** based on the frequency and duration of the activity and resulting noise levels. No mitigation is required.	na	na	na	LS	na	na
Impact N-8: Use of vehicles under the Biological Control Alternative would cause a temporary increase in noise levels during operations. This increase would not be substantial and, therefore, is **less than significant** based on the frequency and duration of the activity and resulting noise levels, and implementation of BMPs. No mitigation is required.	na	na	na	LS	na	na
Impact N-9: Use of equipment and vehicles under the Chemical Control Alternative would increase noise levels during operations, but this increase would not exceed regulatory thresholds. This impact is **less than significant** based on the frequency and duration of the activity and resulting noise levels. No mitigation is required.	na	na	na	na	LS	na

Table 12-11 Summary of Noise Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact N-10: Helicopter/aircraft/airboat use under the Chemical Control Alternative would temporarily increase noise levels during operations, but would not exceed regulatory thresholds. This impact is **less than significant** based on the frequency and duration of the activity and resulting noise levels. No mitigation is required.	na	na	na	na	LS	na
Impact N-11: Use of equipment and vehicles under the Chemical Control Alternative would cause a temporary increase in noise levels during operations. This increase would not be substantial and, therefore, is **less than significant** based on the frequency and duration of the activity, resulting noise levels, comparability to noise resulting from existing activities, and implementation of BMPs. No mitigation is required.	na	na	na	na	LS	na
Impact N-12: Helicopter/aircraft/airboat use under the Chemical Control Alternative would temporarily increase noise levels during operations, but this increase would not be substantial. This impact is **less than significant** based on the frequency and duration of the activity, resulting noise levels, and implementation of BMPs. No mitigation is required.	na	na	na	na	LS	na
Impact N-13: Use of equipment and vehicles under the Other Nonchemical Control/Trapping Alternative would increase noise levels during operations, but this increase would not exceed regulatory thresholds. This impact is **less than significant** based on the frequency and duration of the activity and resulting noise levels. No mitigation is required.	na	na	na	na	na	LS

Table 12-11 Summary of Noise Impacts by Alternative

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact N-14: Use of equipment and vehicles under the Other Nonchemical Control/Trapping Alternative would cause a temporary increase in noise levels during operations. This increase would not be substantial and, therefore, is **less than significant** based on the frequency and duration of the activity, resulting noise levels, comparability to noise resulting from existing activities, and implementation of BMPs. No mitigation is required.	na	na	na	na	na	LS

LS = Less-than-significant impact
N = No impact
na = Not applicable
SM = Potentially significant but mitigable impact
SU = Significant and unavoidable impact

12.2.11 Mitigation and Monitoring

No mitigation measures or monitoring are required because no significant impacts were identified.

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13 Cumulative Impacts

CEQA Guidelines Section 15130 requires that an EIR discuss a project's potential to result in any significant cumulative impacts. "Cumulative impacts" are defined as "two or more individual effects which, when considered together, are considerable or compound or increase other environmental impacts" (CEQA Guidelines Section 15355). The cumulative impact is the change in the environment that results from the incremental impact of the project when added to other closely related past, present, and reasonably foreseeable probable future projects. Cumulative impacts can result from individually minor but collectively significant projects taking place over a period of time. The EIR must determine whether the project's incremental effect is "cumulatively considerable."

> *"Cumulatively considerable" means that the incremental effects of an individual project are significant when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects. (*CEQA Guidelines Section 15065(a)(3))

According to CEQA Guidelines Section 15130(b),

> *The discussion of cumulative impacts shall reflect the severity of the impacts and their likelihood of occurrence, but the discussion need not provide as great detail as is provided for the project alone. The discussion should be guided by standards of practicality and reasonableness, and should focus on the cumulative impact to which the identified other projects contribute rather than the attributes of other projects which do not contribute to the cumulative impact.*

For a project to have a significant cumulative impact, it must have some incremental impact in the category being studied. Thus, when the District's IVMP makes no incremental contribution at all to a significant cumulative impact caused by other plans, programs, and projects, i.e., the "no impact" determination for a Program alternative, it cannot be called cumulatively considerable.

If a project has some potential to contribute to a significant cumulative impact, the CEQA consideration is whether the proposed project's incremental contribution is cumulatively "considerable" (i.e., significant) and, if so, whether the project's incremental contribution can be mitigated to a less-than-significant level. CEQA Guidelines Section 15064 (h)(4) states that the mere existence of significant cumulative impacts caused by other projects alone shall not constitute substantial evidence that the proposed project's incremental effects are cumulatively considerable.

For purposes of this PEIR, the District's Program would have a significant cumulative effect if:

1. *The cumulative effect of related projects (past, current, and probable future projects) without the project are not significant but the project's incremental impact is substantial enough, when added to the cumulative effects, to result in a significant impact; or*
2. *The cumulative effects of related projects (past, current, and probable future projects) without the project are already significant and the project contributes considerably to the effect. The standards used herein to determine considerability are either that the impact must be substantial or must exceed an established threshold of significance.*

Two methods exist for analyzing the cumulative impacts of past, present, and reasonably foreseeable future projects: the "list method" and the "summary of projections method" (CEQA Guidelines Section 15130). Both of these methods are most appropriate to the evaluation of land development or projects involving changes in land use and related activities.

> The list method requires a discussion of related past, present, and future projects; and in the case of human health, it would require discovering and disclosing impacts to public health from all of these projects. This approach is not practical given the Program's extent to its Service Area and adjacent counties for a multicounty Program Area, which makes the development of a list of projects most difficult and would then require a human health impact assessment for a very long list and variety of projects potentially creating a physical change in the environment.

The summary of projections method relies on projections contained in approved land use documents such as general plans, specific plans, and local coastal plans to serve as the foundation for the cumulative analysis. The issue is whether the project under evaluation is consistent with the forecasts of economic and population growth contained in the planning documents and, therefore, already addressed in the certified EIRs on these plans and projects.

The listing of all of the projects occurring in an area is not practical for this evaluation of a Program that could occur over multiple counties in California. The District's IVMP would not result in additional housing or commercial/industrial development in a treatment area. The alternative "summary of projections" method is also not practical because it is based on summaries of growth in city and county plans, which are not relevant for the Program as it does not induce growth or develop land. Because the Program Area is large, the impacts are explained in the context of a regional environmental concern, and the analysis includes consideration of regional trends in pesticide use from 2006 through 2010 (Section 13.4), where appropriate, as an alternative to the growth projections contained in local general plans.

The following discussion of cumulative impacts is for resources and environmental concerns with less-than-significant or potentially significant impacts and the geographic scope of the analysis is the District's Program Area (i.e., Service Area and adjacent counties where service could be provided upon request). A summary of the cumulative impact determinations by affected resources is presented at the end of the chapter.

13.1 Urban and Rural Land Uses

None of the Program alternatives would have any potentially significant impacts on the quantity and/or quality of recreational opportunities within the District's Program Area; however, all of the alternatives except for Biological Control could have less-than-significant impacts. Concerning land use regulations and policies in the Program Area, none of the Program alternatives would have impacts (i.e., determinations of no impact). However, the Chemical Control Alternative may limit recreational access and diminish recreational quality on a short-term basis during application events, a less-than-significant incremental impact. Due to the isolated nature of these events and the extensive recreational opportunities on public lands within the Program Area (i.e., no existing significant cumulative impact within the Program Area), the small incremental potential impacts on recreational opportunities from five of the Proposed Program alternatives when combined would not likely cumulatively contribute to recreational impacts in the region. No cumulative significant impacts to urban and rural land uses are anticipated when all of the Program's incremental impacts and the impacts of other activities in the region are considered together.

13.2 Biological Resources – Aquatic

Cumulative impacts, as they relate to aquatic resources, includes past, present, and reasonably foreseeable actions that potentially impact aquatic organisms, including fish and nontarget invertebrates. Cumulative impacts can result from individually minor, but collectively significant, projects taking place over a period of time. The determination is whether a proposed project's incremental contribution to a cumulative impact results in a potentially "considerable" (i.e., significant) cumulative impact, and, if so, whether that project's incremental contribution can be mitigated to a less-than-significant level.

The following is a discussion of how the Program impacts could become cumulatively considerable with other impacts in the region. To make this determination, consideration is given to the combined

contribution of Program impacts considered together with impacts that exist outside of the Program Area. The issue is whether the Program's incremental contribution to the combined significant cumulative impact is "cumulatively considerable."

The cumulative impact issues addressed first are regional fisheries trends, loss of shallow-water habitats, loss of wetlands, weed control, and trends in pesticide use (Section 13.2.1). Then the impacts by alternative are evaluated (Section 13.2.2).

13.2.1 Regional Fisheries Trends

13.2.1.1 Pelagic Organism Decline (POD)

POD refers to the recent (2002–present) steep decline of pelagic fishes (i.e., fish that occupy open-water habitats) within the Bay-Delta estuary (Armor et al. 2005; CDWR and CDFG 2007; Sommer 2007; Baxter et al. 2010). This environmental issue has emerged as one of overwhelming concern in the Delta.

The issues surrounding POD were announced in early 2005 as a possible change in the estuary's ability to support pelagic species and appeared to be a "step-change" from the preceding long-term decline. Four fish species are of primary concern: delta smelt, longfin smelt, young-of-year striped bass, and threadfin shad. From 2002 to 2007, despite moderate hydrologic conditions in the estuary, which would have been expected to result in moderate increases in population sizes, the populations of these species experienced sharp declines. Populations of each of the four species have been at or near all-time record lows since 2002. The numbers of many pelagic species increased substantially in 2011, but declined again to values near historic lows in 2012, based on the fall mid-water trawl index (CDFW 2013). This change has persisted for a sufficiently long period to conclude that it is the result of something other than the pattern of widely variable population levels observed historically or as part of the long-term decline previously observed.

The factors considered most likely to be responsible for POD are previous abundance of these species; changes in habitat, particularly changes in turbidity and the salinity field in the Delta, invasive weeds and blue green algae blooms, and ammonia and pyrethroid toxicity; predation, particularly from introduced species such as striped bass, largemouth bass, and Mississippi silversides, and entrainment at the Central Valley Project and State Water Project Diversions; food-web effects from invasive clams; and changes in the phytoplankton and zooplankton community (CDWR and CDFG 2007; Sommer 2007; Baxter et al. 2010). These factors result in an existing significant cumulative impact.

Many of the Interagency Ecological Program studies to evaluate POD's causes have focused on these factors. To date, research has failed to identify a single factor responsible for the decline of all species or even that of a single species (CDWR and CDFG 2007; Sommer 2007; Baxter et al. 2010). POD researchers currently believe that important factors responsible for the decline may be different for each species and that even for a single species these factors may differ between seasons and by hydrologic condition (Wet and Dry years). These factors may operate cumulatively to cause the observed population declines.

The POD Management Team has hypothesized that a number of drivers have combined over time to decrease ecosystem resilience and result in a "regime shift" for the Delta and Suisun Bay region (Baxter et al. 2010). The drivers of the hypothesized regime shift include outflow, salinity, landscape, temperature, turbidity, nutrients, contaminants, and harvest. This hypothesis is currently under investigation.

The District borders on San Pablo and Suisun Bays, downstream from the Delta, the Physical Control and Vegetation Management alternatives would contribute to landscape habitat modifications, while the Chemical Control Alternative would contribute to contaminants. The BMPs associated with the implementation of these alternatives substantially reduce these potential effects to be less than significant at the Program level. These less-than-significant Program effects nevertheless contribute to the regional significant impact of POD. However, the fact that the District's activities contribute to the significant cumulative impact does not mean that the District's incremental impacts are themselves cumulatively considerable, as explained below.

> The District's Physical Control and Vegetation Management alternatives are limited to small areas of highly modified habitat. These areas are not primary habitat for POD species. Because the areas where these activities occur are very small relative to the overall area of wetlands in the region, these activities are not expected to have any substantive effect on food production for POD species. These activities would not have indirect effects in terms of nutrient output or other contributions to the food that supports POD species. The District is too far downstream to affect turbidity in areas relevant to POD species, except longfin smelt, a species that likes turbid water. The District's activities would not contribute to the production of invasive weeds. Therefore, these two alternatives do not contribute substantially to POD.

> The Chemical Control Alternative includes the use of pyrethrin and pyrethroid pesticides, which have been linked to POD. The District uses pyrethrin and pyrethroid pesticides as part of an IPM approach, where application of pyrethroids is several levels down in the selection of control measures, so the use of pyrethrins and pyrethroids for adult mosquito control is limited. When pyrethrins and pyrethroids are used, the District preferentially uses those with limited persistence in the environment. The District applies them over aquatic habitats using only ULV application methods, which results in the minimal effective amounts for adult mosquitoes of these chemicals. Furthermore, the District applies these chemicals (for mosquitoes, yellow jackets, and potentially ticks) according to the product labels and BMPs. Labeled application rates for mosquito control tend to be low (compared to rates used for other insects); thus, the amounts of adulticide materials applied over terrestrial and aquatic habitats is low compared to other pest control uses. Thus, the Chemical Control Alternative does not contribute substantially to the concentrations of pyrethrins and pyrethroids in the environment or to POD.

> The Surveillance, Biological Control, and Nonchemical Control Alternatives involve access, monitoring, and control activities with very limited potential to impact POD.

Therefore, all of the Program alternatives together have a less-than-significant cumulative impact on POD. As stated earlier, the District's Program would have a significant cumulative effect if:

> *The cumulative effects of related projects (past, current, and probable future projects) without the project are already significant and the project contributes considerably to the effect. The standards used herein to determine considerability are either that the impact must be substantial or must exceed an established threshold of significance.*

While the effects of related projects without the District's Program are already significant for POD and with the Program are significant as well, the District's Proposed Program does **not contribute considerably to this effect because the District-specific impacts are not substantial** for reasons explained above**.**

13.2.1.2 Salmonid Population Trends

Salmonid population trends were evaluated in a number of 5-year status reviews completed by NOAA Fisheries in 2011 (NOAA Fisheries 2011 a-f). These reviews indicated that most populations of salmonids showed some evidence of decline, although data are very sparse for some distinct population segments (steelhead) or evolutionarily significant units (Chinook and Coho salmon) (also see NOAA 2011g). The declines in the 5-year period of review were largely due in part to poor ocean conditions in 2004 and 2005, which resulted in poor adult returns in 2007 through 2009 and drought (Lindley et al. 2009). However, based on the status reviews for these species, the principal factors resulting in their listing include:

> Loss, degradation, simplification, and fragmentation of habitat caused by a variety of activities including logging, road construction, urban development, mining activities, agriculture, ranching, and recreation

> Reduction or elimination of habitat or blocked access to habitat caused by water storage, withdrawal, conveyance and diversion facilities for agriculture, flood control, and domestic and hydropower purposes

> Point and nonpoint sources of pollution

> Loss of riparian habitats

The Physical Control and Vegetation Management Alternatives would contribute to the first and last factors, while the Chemical Control Alternative would contribute to the third factor. These activities generally occur over small areas and have little impact on primary salmonid habitat. The BMPs associated with the implementation of these alternatives substantially reduce these potential impacts to be less than significant at the Program level, and these alternatives do not contribute substantially to the total amount of habitat loss for salmonids in the region.

The Chemical Control Alternative applies chemicals in aquatic environments at levels that have minimal impacts to fisheries resources or their food supply. BMPs restrict the application of chemicals with higher potential to harm fish from being used in water, and these chemicals are used in very small amounts and with low frequency relative to other sources in the region. The District also preferentially uses chemicals that degrade quickly in the environment, further reducing the risk associated with this alternative. Thus, the Chemical Control Alternative does not contribute substantively to chemical loads in salmonid habitats.

The Surveillance, Biological Control, and Other Nonchemical Control Alternatives involve access, monitoring, and control activities with very limited potential to impact salmonids. Therefore, all of the Program alternatives have a less-than-significant cumulative impact on salmonid population trends.

13.2.2 Program Alternatives

The Surveillance Alternative's maintenance of access routes and the sampling/ monitoring of mosquito and vector populations have less-than-significant impacts on aquatic habitats, native fish or aquatic invertebrates, special-status species, or HCPs and NCCPs along with the Biological Control Alternative's use of mosquitofish in artificial/man-made waterbodies and the trapping associated with the Other Nonchemical Control Alternative are not cumulatively considerable given their limited disruption to natural habitats. Consequently, the focus of the analysis below is on the Physical Control, Vegetation Management, and Chemical Control Alternatives.

13.2.2.1 Physical Control Alternative

The draining or filling of shallow-water habitats in natural areas under the Physical Control Alternative would be cumulative with historic and ongoing impacts to these habitats from other land management practices including flood control, urbanization, and channelization. Some activities occurring as part of the action would occur in artificial environments such as drainage ditches, retention ponds, etc. As described in Section 4.2.4.1, shallow-water habitats can be important habitats for young fish and other sensitive aquatic organisms. Floodplains, off-channel pools and backwaters, and wetlands provide high quality habitat for fry and tadpoles that are subject to predation in deeper, connected habitats. However, where fry are present, they would prey on mosquito larvae and, thus, these areas would likely not need treatment. However, conditions in these habitats may change from seasonally or annually, depending on tides, flows, and precipitation patterns, so that a pool that supports fish or amphibians in one year may not have sufficient water to do so in other years.

This Program's Physical Control Alternative occurs in the context of an environment that for the most part currently is or historically has been highly modified by human use, for agriculture, urbanization, and flood control. It is estimated that more than 90 percent of wetland and riparian habitats in California have been lost to human development (California Natural Resources Agency 2010). Today, recognition of the importance of wetlands is much greater and many wetland protection and restoration projects are underway throughout the state, including, but not limited to, the approved HCP/NCCPs described in Section 4.1.4. Activities affecting wetlands are subject to permitting requirements from a variety of agencies including the USACE, SWRCB or RWQCBs, CDFW, and others. However, wetlands continue to be affected by urban and agricultural development, roadwork, and other activities (California Natural

Resources Agency 2010), an existing significant cumulative impact. The District's activities within this context do not contribute substantially to the cumulative effects of other activities within the region in part due to the constraints of required permits and District BMPs that include advance consultations with resource agencies. Therefore, the Program's impacts are not substantial and would have a less-than-significant cumulative impact on the amount or quality of aquatic habitat.

13.2.2.2 Vegetation Management Alternative

The vegetation within and around aquatic habitats is an important component of the aquatic ecosystem, as described in Section 4.2.5. As described above, historic development has adversely affected wetland communities to a significant level, in spite of their ecological importance. While these communities enjoy much more protection now than they have historically, impacts continue to occur because of human development.

The Vegetation Management Alternative includes measures to remove and maintain vegetation through manual, mechanical, and chemical treatments. Most of the potential for chemical treatment would be relative to artificial environments. Physical and mechanical maintenance activity would occur in artificial and natural environments, where special-status species would not be impacted. Similar activities may be undertaken by flood control or water supply agencies, and private and public landowners.

The District performs vegetation management activities in addition to other vector control activities as part of agreements with landowners and agencies. These vegetation management activities may involve the use of manual, mechanical, and chemical controls to reduce or eliminate noxious weeds. California Food and Agriculture Code 5261 defines a noxious weed as "*any species of plant that is, or is liable to be, troublesome, aggressive, intrusive, detrimental, or destructive to agriculture, silviculture, or important native species, and difficult to control or eradicate, which the Secretary, by regulation, designates to be a noxious weed*."

Numerous entities throughout the Program Area have substantial weed control programs that they implement which is the key issue for cumulative impacts (i.e., ongoing landscape maintenance in developed areas or small-scale vegetation removal for other purposes is not an areawide issue). These entities include California Department of Transportation and local roads departments, local utilities, service districts, government, agricultural districts, and public and private landowners. Information about the coordination of such efforts can be obtained from the CDFA's Noxious Weed Information Project (CDFA 2014a). Fourteen federal, state, and county agencies founded the California Interagency Noxious Weed Coordinating Committee in 1995 to coordinate the management of noxious weeds. This group has assembled a variety of actions for those involved in weed control activities. These actions are designed to minimize disruption of native plants and to improve habitat for them. The District's activities are compliant with these CDFA's Project.

Invasive weeds can disrupt native habitats. They compete with and may displace native plants, which may interfere with ecosystem functions, by altering and reducing the food resources available to primary and secondary consumers. Weed control activities the District performs would be cumulative with those other entities perform. These activities would focus on areas with dense concentrations of weeds and not on individual weed plants distributed broadly in otherwise natural habitats. Thus, weed control activities may affect native plants, as these species may lie within treatment areas, but the effects on individuals of native species are minimized, and the overall effect is likely beneficial, as native species would have less competition in treated areas and, thus, would be expected to be more successful. The District does not contribute substantially to herbicide loads in the aquatic environment. Therefore, a significant cumulative impact to native habitats does not occur. The District's incremental activities associated with vegetation management including the control of invasive weeds would not be cumulatively considerable, i.e., less than significant.

13.2.2.3 Chemical Control Alternative

As described in Sections 13.4 (Ecological Health) and 13.5 (Human Health), historic trends in pesticide use vary from county to county based on information available from CDPR. Within the District's Program Area as a whole, pesticide use decreased by approximately 74,000 pounds in 2010 relative to 2006. This reduction may be due in part to extensive regulatory oversight of pesticide use by the USEPA, CDPR, USFWS, NMFS, SWRCB, CDFW, and others. However, the use of pesticides and herbicides will continue to be necessary. Many of these chemicals exhibit some environmental persistence, and a number of waterbodies have been listed as impaired for sediment toxicity, pesticides, or unknown toxicity (see Table 9-1). The uses of pesticides under the Chemical Control Alternative would be cumulative with uses of pesticides by agricultural, industrial, governmental, and residential users, an existing significant cumulative impact. Contaminants and pesticides have been hypothesized to contribute to declines in fish populations. The District's relative contribution to the loads of such concentrations is small compared with other users for the widely used pesticides in part due to District BMPs. Furthermore, the District's IPM approach preferentially uses nonchemical alternatives and when using chemical alternatives, uses chemicals that are not persistent in the environment; i.e., breakdown within 30 to 150 days. As such, the District's Chemical Control Alternative does not contribute substantially to pesticide loads in the aquatic environment. The Chemical Control Alternative has a less-than-significant cumulative impact on pesticide loads.

13.3 Biological Resources – Terrestrial

Cumulative impacts, as they relate to terrestrial resources, include past, present, and reasonably foreseeable actions that potentially impact terrestrial mammalian and avian wildlife, herptiles, aquatic organisms, nontarget invertebrates and pollinators, and botanical resources. Cumulative impacts can result from individually minor, but collectively significant, projects taking place over a period of time. The determination is whether a proposed project's incremental contribution to a cumulative impact results in a potentially "considerable" (i.e., significant) cumulative impact, and, if so, whether that project's incremental contribution can be mitigated to a less-than-significant level.

The following is a discussion of whether the Program impacts could become cumulatively considerable with other impacts in the region. To make this determination, consideration is given to the combined contribution of Program impacts considered together with impacts that exist outside of the Program Area. The issue is whether the Program's incremental contribution to the combined significant cumulative impact is "cumulatively considerable."

In summary, only the Program alternatives' less-than-significant and potentially significant impacts have the potential to add an incremental effect to a cumulatively significant impact. In Section 5.2, the Surveillance, Physical Control, Vegetation Management, Chemical Control, and Other Nonchemical Control Alternatives impacts to terrestrial resources were determined to be less than significant. (The Biological Control Alternative's use of mosquitofish had no impact to terrestrial resources.) The key issues for consideration herein are potential effects on beneficial insect pollinators from chemical applications and the potential cumulative impacts associated with Vegetation Management and Chemical Control Alternatives.

Program alternative impacts to terrestrial resources were identified as "less than significant" (LS) if the likely exposure to terrestrial habitats, to native terrestrial plant or animal populations, or to special-status species was either very short or the application medium (as a fog or liquid) was typically highly dilute (ULV techniques). Additionally, the LS determination was applied if it was indicated that exposure could be considered likely incomplete due to little or no overlap of application areas and typical habitat associated with nontarget special-status or sensitive terrestrial species.

13.3.1 Effects on Pollinators

Some of the currently available insecticides used to control mosquitoes and yellow jackets may also exhibit toxicity to selected beneficial insects. The District employs a number of strict BMPs specifically designed to minimize or eliminate the impact of chemical treatments on nontarget insects such as honeybees. Of particular concern recently is a group of insecticides known as neonicotinoids, which target the nervous system of target insects, resulting in paralysis and death (Harmon 2012). Reports implicate this group of pesticides as one of the possible contributors to reported decreases in bee colonies, known as colony collapse disorder (CCD). This disorder and the resulting decline in bee populations is an existing significant cumulative impact in the region. As reported, CCD has been used to correlate some reports of the apparent disappearance of honeybees from hives. A recent in situ study attempted to replicate CCD wherein the authors claimed that the only variable that contributed significantly to hive death was exposure to sublethal levels of imidacloprid (a commonly used neonicotinoid insecticide), although the authors reported mortalities in bees that were fed only contaminated fructose (large doses of the insecticide) (Lu et al. 2012). After this report was published, peer reviews of the article indicated that the methodology was substantially flawed by the use of extremely high levels of pesticides in the tests that are actually already known to be very toxic to bees (400 ppb) when fed directly with no opportunity to obtain alternate, uncontaminated sources of food (fructose).

In addition to the potential impacts of some pesticides on bees, it is clear that many other factors can impact bee colonies in their hives. Activities such as housing development and expansion of public projects decrease the number and proximity of orchards, and in many urban or semiurban areas the restrictions on keeping bees severely limit the number of hives. These activities, in conjunction with vector control activities, can be considered cumulatively considerable, without precisely accounting for relative impacts to bee colonies. The claims that the problems with bee colonies are purely due to pesticide applications are not supported.

As an example of the conservative nature of pesticide applications the District practices, the District does not use neonicotinoid insecticides (e.g., imidacloprid and other pesticides recently claimed to be associated with CCD) and is not considering them for future use. As a result, the vector control and maintenance programs the District uses have not been associated with CCD. Insect control activities the District performs would be cumulative with vector control programs and habitat maintenance activities of other, sometimes nearby, private and/or public groups perform that are within the range of influence of the beehives of interest. In general, while it is true that insect abatement activities may affect native pollinators near or adjacent to treatment areas, the District's careful practice of BMPs greatly reduces the potential cumulative impacts to nontarget pollinators. Based on these conclusions, the Program's less-than-significant impacts on insect pollinators related to mosquito and yellow jacket abatement activities would not be cumulatively considerable or significant.

13.3.2 Vegetation Management

The District performs vegetation management of mosquito-breeding habitat and weed abatement activities for vector habitat management in addition to other vector control activities as part of agreements with landowners. These vegetation management activities may involve the use of manual, mechanical, and chemical controls to manage vegetation that precludes or renders access for vector control difficult or which provides habitat for vectors (e.g., mosquitoes) and/or reduce or eliminate noxious weeds pertaining to vector control. California Food and Agriculture Code 5261 defines a noxious weed as "any species of plant that is, or is liable to be, troublesome, aggressive, intrusive, detrimental, or destructive to agriculture, silviculture, or important native species, and difficult to control or eradicate, which the Secretary, by regulation, designates to be a noxious weed."

Numerous entities throughout the Program Area have weed control programs and activities that they implement. These entities include the California Department of Transportation and local roads

departments, local utilities, service districts, government, agricultural districts, and public and private landowners. Information about the coordination of such efforts can be obtained from the CDFA's Noxious Weed Information Project (CDFA 2014). Fourteen federal, state, and county agencies founded the California Interagency Noxious Weed Coordinating Committee in 1995 to coordinate the management of noxious vegetation.

Invasive vegetation can disrupt native habitats. It competes with and may displace native plants. This tendency may interfere with ecosystem functions, by altering and reducing the food resources available to primary and secondary consumers. Weed control activities the District performs would be cumulative with those other entities perform. Weed control activities may affect native plants, as these species may lie within treatment areas, but the effects on individuals of native species are minimized, and the overall effect is likely beneficial, as native species will have less competition in treated areas and, thus, would be expected to be more successful. Based on this conclusion, the Program's incremental less-than-significant effects relating to vegetation management and weed abatement activities including herbicides would not, when considered with other weed abatement activities in the Program Area, be cumulatively considerable or significant.

13.3.3 Chemical Control Alternative

As described in Section 13.4 (Ecological Health), historic trends in pesticide use vary from county to county based on information available from CDPR. Within the District's Program Area as a whole, pesticide use varies by county in 2010 relative to 2006 including reductions in Napa and Lake Counties' pesticide use. This reduction may be due in part to regulatory oversight of pesticide use by the USEPA, CDPR, USFWS, NMFS, SWRCB, CDFW, and others is extensive. However, the use of pesticides and herbicides will continue to be necessary. Many of these chemicals exhibit some environmental persistence. The uses of pesticides under the Chemical Control Alternative would be cumulative with uses of pesticides by agricultural, industrial, governmental, and residential users, an existing significant cumulative impact. The District's relative contribution to the loads of such concentrations is small compared with other users for the widely used pesticides in part due to BMPs. Furthermore, the District preferentially uses nonchemical alternatives and when using chemical alternatives, uses chemicals that are not persistent in the environment; i.e., breakdown within 30 to 150 days. As such, the District's Chemical Control Alternative does not contribute substantially to pesticide exposures in the terrestrial environment. The Chemical Control Alternative has a less-than-significant cumulative impact on terrestrial resource exposures to pesticide loads.

13.4 Ecological Health

Cumulative impacts, as they relate to ecological health include past, present, and reasonably foreseeable actions that potentially impact aquatic/terrestrial mammalian and avian wildlife, herptiles, aquatic organisms, nontarget invertebrates and pollinators, and botanical resources. See also Sections 13.2 Aquatic Resources and 13.3 Terrestrial Resources for additional discussion of cumulative impacts. To make a determination of a cumulatively considerable impact, consideration is given to the combined contribution of Program impacts (mostly less than significant) considered together with impacts that exist outside of the Program from the activities of agencies and individuals. If those impacts, taken all together result in a significant impact, then the Program's incremental contribution to the combined significant cumulative impact is "cumulatively considerable" if it triggers the significant cumulative impact or if it has a substantial contribution to the existing significant cumulative impact

The Proposed Program does result in the use of pesticides and a potential increase in pesticide use over existing conditions for certain formulations. Local planning agencies, County Agricultural Commissioners, and CDPR do not forecast future pesticide use. However, the cumulative analysis for ecological health concerns can address the question of increases in pesticide use as a result of the Proposed Program as a variation of the "summary of projections method" to address regional cumulative impacts of pesticide

use and whether the incremental contributions of the Program's chemical treatment methods contribute to cumulative significant ecological health-related impacts. The estimates of total pesticide use by all users in the District's Program Area are not based on population or housing units or employees in the state but rather on past trends in pesticide use from available data on pesticide sales of products, as active ingredients, reported to the CDPR for 2006-2010. The analysis seeks to provide the regional context needed for a reasonable discussion of cumulative impacts. Just as local and regional plans project growth based on past trends, the analysis below relies on past trends to address changes in pesticide use and potential cumulative ecological health impacts.

This analysis considers whether potential exists for any incremental contribution of chemical use from the Program, when combined with other reasonably foreseeable uses of the specific pesticides considered in this PEIR (and Appendix B), which would result in cumulative impacts that could be considered "cumulatively considerable" to ecological health. The District's activities would involve the application of low concentrations of selected pesticide and herbicide active ingredients. Further, the District's practices including avoidance of some habitat types and strict adherence to stay within product label maximum application amounts, which typically require concentrations well below known toxicity values, would result in relatively short exposures. Program alternative impacts were identified as "less than significant" if the likely exposure to nontarget species was either very short or the application medium (spray or liquid) was typically highly dilute (ULV techniques). Additionally, the less-than-significant determination was applied if it was indicated that exposure could be considered likely incomplete due to little or no overlap of application areas and typical species habitat.

13.4.1 Trends in Pesticide Use 2006–2010

Trends in pesticide use help to determine whether a cumulatively considerable impact exists in the region from the use of pesticides (including herbicides) by all agricultural, industrial, governmental, and residential users. In general, a significant cumulative impact exists from the quantities of materials applied overall with some reductions in use of selected materials. Table 13-1, Historical Pesticide Use by All Users in the MSMVCD Program Area, illustrates the changes in relative pesticide use by all users (as pounds per year of active ingredients) for 46 chemicals in the counties represented in the District's Program Area (Service Area plus adjacent counties), which is the focus of Appendix B for this PEIR. After inspection of the yearly data reported by the CDPR, it is difficult to determine any repeatable or linear trends in use patterns. The potential cumulative impact of the use of similar pesticides by numerous agencies, organizations, and individuals in the counties suggests that many potential interactions could lead to cumulative pesticide impacts without definitive determination of the relative volume of each of the sources. However, pesticide use in the Program Area overall has decreased since 2006. The amount of active ingredients used in the Program Area in 2006 was approximately 4,282,839 pounds (2,141 tons), whereas it decreased to 4,208,767 pounds (2,104 tons) in 2010 (CDPR).

Although the reported cumulative pesticide product used has a very wide range for each county in the table, some generalities can be made for each county although the data are limited to 2006 to 2010:

> Marin County reported 4.9 tons more pesticides used in 2010 than in 2006

> Sonoma County reported 21 tons more pesticides used in 2010 than in 2006

> Napa County reported more than 140 tons fewer pesticides use in 2010 than in 2006

> Solano County reported slightly more than 131 tons of pesticides used in 2010 than in 2006

> Mendocino County reported using essentially the same amount of pesticides in 2010 as in 2006

> Lake County reduced its pesticide use by 65 tons between 2006 and 2010

Table 13-1 Historical Pesticide Use by All Users within the MSMVCD Program Area[1]

Active Ingredient[2]	Vector	Service Area Counties						Adjacent Counties											
		Sonoma			Marin			Napa			Solano			Mendocino			Lake		
		2006	2008	2010	2006	2008	2010	2006	2008	2010	2006	2008	2010	2006	2008	2010	2006	2008	2010
2,4-D	Herbicide	3215	33478	2788	1132	1176	1038	509	595	354	27481	33478	25791	202	148	167	256	501	1041
Alcohol Ethoxylated Surfactant	Mosquito	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b
Aliphatic Solvents	Mosquito	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b
APEs	Herbicide	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b
Allethrins	Mosquito, Yellow Jacket / Wasp	0.5	0.3	6.3	0.2	0.2	0.1	0.1	0.2	0.1	0.3	0.3	0.2	0.1	0.1	0.1	0.1	0.1	
Bs	Mosquito	435.9	0.9	1026.7	125.3	317.2	282.1	0.5	9.7	2.1	9.8	0.9	0.4	b	b	b	b	0.1	180
Bti	Mosquito	762	3.9	994	527	648	1220	50.6	48.9	44.7	9.1	3.9	2.3	b	b	b	943	1135	373
Benfluralin (Benefin)	Herbicide	43.3	90.9	72.7	b	b	b	b	b	b	60.2	90.9	2.8	0.01	0.2	b	0.02	b	b
Bentazon	Herbicide	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b
Brodifacoum	Rodents	0.05	0.02	0.03	0.01	b	b	0.02	0.02	0.01	0.02	0.02	0.03	0.01	0.01	0.02	b	0.01	b
Bromadiolone	Rodents	0.3	0.2	0.3	0.4	0.4	0.5	0.2	0.2	0.2	0.3	0.2	0.3	0.05	0.06	0.02	0.03	0.04	b
Chlorophacinone	Rodents	0.05	0.01		0.06	0.02	0.03	0.06	0.04	0.04	0.01	0.01	b	b	b	b	0.01	b	b
Cholecalciferol	Rodents	0.05	0.08	0.3	0.03	0.03	0.2	0.03	0.03	0.1	0.6	0.08	0.03	b	b	0.1	b	b	b
DCPA	Herbicide	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b
Deltamethrin	Mosquito, Yellow Jacket / Wasp	40.3	55.8	108.4	14.8	7.2	19	5.9	4	4.6	75.4	55.8	45.3	0.6	0.4	2	10	10	0.2
Difethialone	Rodents	b	b	0.04	b	b	0.05	b	b	0.01	b	b	0.1	b	b	0.01	b	b	b
Diphacinone	Rodents	0.2	4	0.2	0.2	0.1	0.2	0.07	0.2	0.5	0.6	4	0.3	b	b	b	0.06	0.2	0.03
Dithiopyr	Herbicide	119.6	270	81.3	0.5	10.3	46.4	58.6	33.9	24.9	34.1	270	780.5	b	b	10	b	b	b
Diuron	Herbicide	1847	17130	576.4	204.8	329	69.5	4976	5524.5	4152.9	21737	17130.4	4813.3	561	383	160	2993	2782	580
Esfenvalerate	Yellow Jacket / Wasp	0.4	1034.6	3.6	0.8	0.5	1.2	b	0.4	0.3	251.3	1034.6	264.7	49	52	50	5	87	27
Etofenprox	Mosquito, Yellow Jacket / Wasp	b	b	1.3	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b
Glyphosate	Herbicide	79879	77952	94726	2957	2763	5994	44422	32514	39832	80536	77951	112532	13592	12144	14094	14065	12045	7424
Imazapyr	Herbicide	163.5	5.5	148.3	34.5	37	18.3		24.8	20.9	b	5.5	18.3	5171	3432	5886	b	81	b
Lambda-cyhalothrin	Mosquito, Yellow Jacket / Wasp	62.8	1043	12	18.6	142.9	26.7	16.8	18.4	5.4	519.6	1042.6	889.4	6.7	4.3	8	2.6	3	0.4
Lecithin	Herbicide	547	310.6	581.2	6.1	3.3	31.7	184.9	303.3	1022.7	476.3	310.6	521.8	165	301	253	20	83	108
Methoprene	Mosquito	236	299	256.4	73	95	73	69	49	29.5	231	298	277	0.1	0.01	0.1	19	15	14
Metolachlor	Herbicide	b	13444	b	b	b	b	b	b	b	12771	13434	17020	b	b	b	b	b	b
Modified Vegetable (Plant) Oil	Herbicide	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b
Naled	Mosquito	b	b	0.2	b	b	b	b	b	0.1	195.8	b	b	66	b	b	b	b	b
Oryzalin	Herbicide	3047	17648	1788.6	76.8	104.2	354.3	5606	2726.2	1867.4	6610	17648.4	4618.1	411	676	250	341	2113	407
Pendimethalin	Herbicide	2879	15031	12021.3	897.4	592.6	212.5	402.5	138	2641.4	8666	15030.9	20641.3	13	b	535	1025	660	392
Permethrin	Mosquito, Yellow Jacket / Wasp	974	446.8	842.1	734.9	758.3	373.4	336	246.3	141.9	458.3	446.8	1360	159	44	14	272	139	117
Phenothrin	Yellow Jacket / Wasp	0.2	0.2	0.4	0.2	0.4	0.5	b	0.1	0.1	0.2	0.2	0.3	0.06	0.03	0.05	0.1	2	b

Table 13-1 Historical Pesticide Use by All Users within the MSMVCD Program Area[1]

Active Ingredient[2]	Vector	Service Area Counties						Adjacent Counties											
		Sonoma			Marin			Napa			Solano			Mendocino			Lake		
		2006	2008	2010	2006	2008	2010	2006	2008	2010	2006	2008	2010	2006	2008	2010	2006	2008	2010
PBO	Mosquito	153	338.4	469	70	74	218	191	220	210	212	338.4	425.3	17	17	36	838	409	486
Polydimethylsiloxane Fluids	Herbicide	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b
Potassium Salts	All	12346	3583	21940	17712	29300	23284	7118	6834	16682	11399	3592	5457	568	389	2778	349	136	2360
Prallethrin	Mosquito	b	b	0.1	b	b	0.3	b	b	1	b	b	1.2	b	b	b	b	0.4	b
Pyrethrins	Mosquito, Yellow Jacket / Wasp	45	87.8	92.9	14.2	20.3	31.9	78.6	147.9	67.1	42.2	87.8	108.6	31	21	32	60	42	30
Resmethrin	Mosquito, Yellow Jacket / Wasp	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b	b
Sodium Nitrate	Fumigant	0.8	1.8	b	b	b	b	b	b	b	b	1.8	0.2	b	b	b	b	b	b
Spinosad	Mosquito	55.7	1.2	42.5	16	15.3	10.2	4.5	1.1	210.9	3	1.2	28.3	172	19	13	197	15	16
Sulfometuron methyl	Herbicide	31	197.2	79.9	0.3	5.4	17.5	89.7	134	119.3	113.2	197.2	134.8	11	0.8	0.6	2	10	b
Sulfur	Fumigant	1801508	232318	1811461	2468	1529	3699.7	1127323	709824	843504.8	220538	232318	458364.1	498855	483366	497529	237693	158232	115812
Temephos	Mosquito	b	b	b	b	b	b	0.1	b	0.3	b	b	b	b	b	b	b	b	b
Tetramethrin	Yellow Jacket / Wasp	0.03	0.01	b	b	b	b	b	b	b	b	0.01	b	b	b	b	b	0.01	b
Triclopyr	Herbicide	1235	3604	1535	576	619	464	132	125	97	2037	3604	2877	169	643	420	196	72	3
Total		**1909628**	**418380**	**1951656**	**27661**	**38549**	**37487**	**1191575**	**759523**	**911038**	**394468**	**418378**	**656976**	**520220**	**501641**	**522238**	**259287**	**178573**	**129371**

Notes:

[1]From the California Department of Pesticide Regulation, Pesticide Use Reporting database.

[2]All values are reported in weight (lbs) of Active Ingredient used in a county over the given year.

b = Blank cells mean that either no use was reported for that chemical in that county in that year or the reported data was less than 0.005 lb. Because data are usually reported as pounds of product, and the active ingredient needs to be calculated, the CDPR database has apparent problems for some of the chemicals used in quantities greater than the 0.005-pound threshold for reporting the pounds of active ingredient.

Pesticide use by all users in the District's Service Area (i.e., only Marin and Sonoma counties) was 1,937,289 pounds (969 tons) in 2006, which increased by almost 3 percent to 1,989,146 pounds (995 tons) in 2010. Although large uncertainty and high variation exist in the reported amounts of pesticide use by all users within these counties, they vary according to their particular needs, majority of habitat type, and seasonal vector outbreaks.

The District uses BMPs in its pesticide applications for mosquito and vector control and is attempting to reduce its total pesticide use where possible consistent with integrated vector management practices. The District's annual use of pesticides is reported to the Marin and Sonoma County Agricultural Commissioners and provided here in Table 13-2, Pesticide Use by MSMVCD within the District Service Area, 2006–2010. Table 13-2 provides pounds of total pesticide product used by active ingredient. Pounds of active ingredient (excluding all other inert ingredients) were estimated for some of the products and shown in parentheses next to the pounds of total product. Although the units in Table 13-2 vary from Table 13-1 (which is pounds of active ingredient) and are reported by product name, comparisons for the two most heavily used Bs formulations (VectoLex CG and VectoLex WDG) are 6,408 pounds in 2006 and 11,062 pounds in 2010. This weight is for the total product, not just the active ingredient. For two of the three most heavily used VectoLex formulations, the amount of active ingredient Bs would be approximately 653 pounds in 2006 and 1,140 pounds in 2010. The active ingredient in this example is approximately 10 percent of the total product amount. Pesticide product use by the District is affected by population growth, weather conditions (rainfall), and restoration projects in the Service Area. Also, at selected sites a large amount of product may have to be used or is required to abate a significant mosquito/vector problem, e.g., wastewater treatment plant and wetlands with invasive vegetation.

The incremental effects of the District's use of four pesticides with the potential to bioaccumulate in the environment (i.e., including methoprene and spinosad for mosquito larvae; esfenvalerate and etofenprox for adult mosquitoes/yellow jackets/ticks) do not contribute substantially to large-scale bioaccumulation and regional impacts to ecological health. The limited number and use of the adult insect products (esfenvalerate and etofenprox) in relation to the area of application is inconsequential in the context of existing organisms not being subject to continuous exposure. Although spinosad and methoprene have been designated as potential bioaccumulators, the environmental conditions on the ground and in water after an application of one of these pesticides by the District generally does not provide the continuous exposure needed for substantial bioaccumulation in nontarget organisms. The impact of District applications of these pesticides that could contribute to the bioaccumulation of these pesticides in nontarget animals and the environment is short-lived with such a small fraction of their overall normal exposure to outside stress as to be unremarkable. The four pesticides that have the potential to bioaccumulate are used in such low doses, usually with special application restrictions, and in such prescribed areas as to not substantially impact the regional environment and are not cumulatively considerable.

The District's incremental contributions to overall pesticide use within its Program Area do not trigger a cumulatively considerable impact. While the overall use of pesticides throughout the Program Area may be considered cumulatively significant based on the use of a long list of active ingredients and quantities used by all users, and since the District is a major user of a few of these pesticides, the District's less-than-significant incremental contributions to this large-scale existing impact are not cumulatively significant because the District does not use the ingredients with the greatest potential to harm nontarget species. For chemicals used, label requirements and District BMPs substantially avoid or minimize potential impacts. Therefore, the Program's long-term activities including chemical applications would not contribute considerably to nontarget ecological receptor impacts. The Program alternatives involving chemical use would not result in significant cumulative impacts to the ecological health condition of the region.

Table 13-2 Pesticide Use by MSMVCD within the District Service Area

Pesticide (units)[a]	Active Ingredient	Amount of Product (or Active Ingredients)		
		2006	2008	2010
Herbicides				
Habitat (gal)	Imazapyr	0.00	0.55	0.00
Liberate (gal)	Alcohol ethoxylate	0.00	0.55	0.00
Larvicides				
BVA 2 (gal)	Mineral oil	0.00	0.00	681.73
Golden Bear 1111 (gal)	Mineral oil	531.19	892.06	87.66
Agnique MMF (gal)	Alcohol ethoxylate	41.28	29.81	52.33
Agnique MMFG (lbs)	Alcohol ethoxylate	0.00	33.00	0.00
VectoBac 12AS (gal)	Bti	929.78 (106.6)	631.24 (69.41)	759.38 (83.5)
VectoBac Corncob Granules - BTI (lbs)	Bti	25.09	509.24	770.40
VectoBac Technical Powder (lbs)	Bti	53.54	57.12	3.28
VectoBac WDG (lbs)	Bti	0.00	0.00	14.00
VectoLex WSP (lbs)	Bs	18.13	29.16	22.72
VectoLex CG (lbs)	Bs	6227.58 (561)	7873.18 (590)	10,734.42 (974)
VectoLex WDG (lbs)	Bs	180.64 (91.8)	299.98 (153)	327.40 (166)
VectoMax CG (lbs)	Bs and Bti	0.00	0.00	3990.02 (974)
Altosid Liquid Larvicide (gal)	Methoprene	97.05	18.20	50.20
Altosid Liquid Larvicide SR20 (gal)	Methoprene	0.00	0.00	0.35
Altosid Briquets (small) (lbs)	Methoprene	24.95 (0.3)	12.83 (0.151)	11.39 (0.12)
Altosid Pellets (lbs)	Methoprene	1516.69 (68)	1787.20 (80.4)	1052.14 (47)
Altosid SBG (lbs)	Methoprene	0	6.3	2.7
Altosid Briquets XR (lbs)	Methoprene	773.55 (16.3)	905.36 (19)	829.58 (17)
Altosid XR granules (lbs)	Methoprene	15.92	0.01	0.00
Adulticides				
Pyrocide 5% (gal)	Pyrethrin	55.53 (1.1)	36.95 (0.41)	74.96 (0.81)
Scourge 4% + 12% MF (gal)	Resmethrin	0.00	1.83	0.00
Zenivex (gal)	Etofenprox	0.00	0.00	0.90
Pesticides				
Wasp Freeze (can)	Phenothrin	0.38	0.82	0.59
Delta Dust (lbs)	Deltamethrin	1.62	0.06	23.90
Drione Insecticides (lbs)	Pyrethrin	50.63	52.12	27.99
Other				
Mosquitofish (each)		10828	17485	19635
Sand (lbs)		1188.81	1271.13	73.00

Source: Marin/Sonoma Mosquito and Vector Control District, pesticide use reports.

Notes:

[a] Unit of measure is for total product used and number of mosquitofish except for number in parentheses which is the estimated amount of active ingredient only.

13.5 Human Health

Cumulative impacts, as they relate to human health, include past, present, and reasonably foreseeable actions that potentially impact humans. Cumulative impacts can result from individually minor, but collectively significant, projects taking place over a period of time. To make a determination of a cumulatively considerable impact, consideration is given to the combined contribution of Program impacts (mostly less than significant) considered together with impacts that exist outside of the Program from the activities of agencies and individuals. If those impacts, taken all together result in a significant impact, then the Program's incremental contribution to the combined significant cumulative impact is "cumulatively considerable" if it triggers the significant cumulative impact or if it has a substantial contribution to the existing significant cumulative impact.

The Proposed Program does result in the use of pesticides and a potential increase in pesticide use over existing conditions for certain formulations. Local planning agencies, County Agricultural Commissioners, and CDPR do not forecast future pesticide use. However, the cumulative analysis for human health concerns can address the question of increases in pesticide use as a result of the Proposed Program as a variation of the summary of projections method to address regional cumulative impacts of pesticide use and whether the incremental contributions of the Program's chemical treatment methods contribute to cumulative significant human health-related impacts. The estimates of total pesticide use by all users in the District's Program Area provided in the preceding analysis in Section 13.4 (Table 13-1) are not based on population or housing units or employees in the state but rather on past trends in pesticide use from available data on pesticide sales of products, as active ingredients, reported to the CDPR. The analysis seeks to provide the regional context needed for a reasonable discussion of cumulative impacts. Just as local and regional plans project growth based on past trends, the analysis below relies on past trends to address changes in pesticide use and potential cumulative human health impacts.

This analysis considers whether potential exists for any incremental contribution of chemical use from the Program, when combined with other reasonably foreseeable uses of the specific pesticides considered in this PEIR (and Appendix B), which would result in cumulative impacts that could be considered "cumulatively considerable" to human health. The District's activities would involve the application of low concentrations of selected pesticide and herbicide active ingredients. Further, the District's practices including minimization or avoidance of impacts to some habitat types (such as tidal marshes and seasonal wetlands including vernal pools) and strict adherence to product labels, which typically require concentrations well below known toxicity values, would result in very short exposures. Program alternative impacts were identified as "less than significant" if the likely exposure to humans was either very short or the application medium (spray or liquid) was typically highly dilute (ULV techniques). Additionally, the less-than-significant determination was applied if an indication existed that exposure could be considered likely incomplete due to little or no overlap of application areas.

The District's incremental contributions to overall pesticide use within its Program Area do not trigger a cumulatively considerable impact. While the overall use of pesticides throughout the Program Area may be considered cumulatively significant based on the use of a long list of active ingredients and quantities reported by all users, the District's incremental contributions to this overall impact are not cumulatively significant largely because label requirements and BMPs mitigate for potential impacts. Therefore, the Program's long-term activities including chemical applications would not contribute considerably to human health impacts. The Program alternatives would not result in significant cumulative impacts to the human health condition of the region.

13.6 Public Services and Hazard Response

The District's Program would not incrementally increase demand for police, fire, or health-care services, nor would it create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials, through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment, or through the operation of aircraft. In addition, the Program would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. In short, the Proposed Program does not have incremental impacts on public services, and implementation of any of the Program alternatives (individually or in combination) would not result in a significant contribution to any cumulative public services and hazard response impacts that could result from other projects in the vicinity of the treatment areas.

13.7 Water Resources

Less-than-significant impacts to water resources are identified for all Program activities In summary, several receiving waters in the Program Area are already included on the CWA 303(d) list as impaired by pesticides, pyrethroids, or sediment toxicity, with the likely cause being the use of common household insecticides containing pyrethroids by members of the public, not vector control activities the District conducts. Where receiving waters (such as San Pablo Bay or Central San Francisco Bay) have been designated as impaired by pesticides, pyrethroids, or sediment toxicity, an existing significant cumulative impact is associated with the combined applications of these pesticides. The District's use now or in the future of some of the more toxic and persistent pyrethroids (permethrin and resmethrin) would be unlikely to contribute to impairments of receiving water identified on the CWA 303(d) list as caused by pyrethroids and sediment toxicity primarily because the method of application. Several studies have shown that pyrethrins applied using ULV techniques do not accumulate in water or sediment following repeated applications. These studies also determined that no toxicity is associated when exposure is limited to the amounts used when following ULV protocols for mosquito control (Lawler et al. 2008; Amweg et al. 2006). Concerning permethrin, when applied in accordance with ULV label instructions, studies have shown rapid dissipation, low persistence, and no observed aquatic fish and invertebrate toxicity following aerial ULV applications (Appendix B). Although one study found higher levels of permethrin on the surface microlayer of the waterbody, corresponding water samples did not contain detected residues, and higher surface microlayer concentrations were not correlated with toxic effects in the waterbody. When applied directly to ground nests of yellow jacket wasps or around residences or parks for tick abatement, the product is used with careful techniques such as controlled applications to very small, localized areas.

Where receiving waters have been designated as impaired for pesticides used under the District's IVMP, a cumulatively considerable impact results from all uses of these pesticides or the receiving waters would not be designated as impaired. The District's use of these "impairment chemicals" is contributing in less-than-significant amounts to an existing cumulatively considerable impact in the Program Area and are not cumulatively considerable. No additional impacts were identified in association with the chemical and nonchemical Program alternatives, and no additional cumulative impacts are anticipated to occur (i.e., the District's less-than-significant impacts are not triggering a new cumulative impact).

13.8 Air Quality

Impacts to regional ambient air quality by all Program alternatives would be less than significant for criteria pollutant emissions. The majority of air districts in California, including BAAQMD and NSCAPCD assume that if project-level emissions do not exceed significance thresholds, and no closely related project exists, then a project would not have a cumulatively considerable impact on air quality. In most of the areas the District is likely to target for Program activities, related projects would be similar programs other Districts conduct in their respective jurisdictions and CDFA's special campaigns to control specific threats such as gypsy moths, light brown apple moths, and Mediterranean fruit flies. These projects would not occur at the same times (days) and same locations. All of the Program alternative emissions

(separately and combined for the District's entire Program) would be below the significance thresholds for criteria pollutant emissions. The incremental impacts on air quality from the Program alternatives are not individually significant nor are they cumulatively considerable. Therefore, cumulative impacts to regional air quality are less than significant.

The VOC emissions resulting from the volatilization of the products during applications of pesticides and herbicides are relatively inconsequential when compared to the sources from vehicles and mechanical equipment used during the application. The VOCs associated with pesticide use are a small fraction of the total emissions the District produces. Concerning the cumulative impact of the District's pesticide use when combined with pesticide use by agriculture, the CDPR restricts use of many agricultural pesticide products that are high in VOCs to comply with the CAA. Statewide use of agricultural pesticides on commercial crops account for approximately 2 percent of all VOCs produced in the state, while the VOC emissions of pesticides and herbicides the District typically uses for vector control are minimal to insignificant. State restrictions include some high-VOC products containing abamectin, chlorpyrifos (not used extensively), gibberellins, or oxyfluorfen (used primarily on some Central California crops), and this concern should not impact District use of pesticides for vector control. (CDPR 2014c)

13.9 Greenhouse Gases and Climate Change

Scientific consensus concurs that global climate change will increase the frequency of heat extremes, heat waves, and heavy precipitation events. Currently accepted models predict that continued GHG emissions at or above current rates will induce more extreme climate changes during the 21st century than were observed during the 20th century. A warming of about 0.2°C per decade is projected. Even if the concentrations of all GHGs and aerosols are kept constant at year 2000 levels, a further warming of about 0.1°C per decade would be expected. A faster temperature increase will lead to more dramatic, and more unpredictable, localized climate extremes. Other likely direct effects of global warming include an increase in the areas affected by drought, an increase in tropical cyclone activity and higher sea level, and the continued recession of polar ice caps. Already some identifiable signs exist that global warming is taking place. In addition to substantial ice loss in the Arctic, the top seven warmest years since the 1890s have been after 1997. (IPCC 2007)

The overall global climate change will be comprised of social and economic losses. These negative effects will likely be disproportionately shouldered by the poor who do not have the resources to adapt to a change in climate. Some of the main ecosystem changes anticipated are that biodiversity of terrestrial and freshwater ecosystems could be reduced and that the ranges of infectious diseases would likely increase.

Cumulative impacts were assessed in a qualitative manner by determining if the Program alternatives, in conjunction with other projects throughout the Program Area, would have the potential to contribute to a long-term cumulative impact on climate change. Given that GHG emissions and climate change are global issues, a statewide framework or cumulative approach for consideration of environmental impacts may be most appropriate. Virtually every project in California, as well as those outside the state, would have GHG emissions.

All Program alternatives would generate some GHG emissions individually but would not conflict with current plans, policies, and regulations. No potentially significant impact would occur as a result of any of the Program alternatives (individually or when combined for the entire Program), and no mitigation is required for GHGs and climate change. However, optional mitigation measures (BMPs) for all alternatives are listed in Section 11.2.11. Even with mitigation, the alternatives would generate GHG emissions and incrementally contribute to climate change, however minor.

When all Program emissions are viewed in combination with global emission levels that are contributing to the existing cumulative impact on global climate change, the incremental contribution of these Program emissions would not be cumulatively considerable because they occur intermittently on a very small scale (i.e., not stationary sources). Therefore, all Program alternatives (either individually or in combination) would

not have a cumulatively considerable impact on global climate change. If optional mitigation measures (BMPs) are implemented, the Program alternatives' incremental contribution would be reduced further.

13.10 Noise

Program activities would result in temporary, sporadic noise impacts from equipment use, and any given surveillance or treatment area would be affected only for a brief period. Cumulative impacts would result from the implementation of Program activities in combination with those of other reasonably foreseeable projects and actions occurring at the same time and in the same place. The likelihood of this happening and resulting in noise levels that would exceed thresholds or cause a substantial temporary increase in noise levels is remote; moreover, noise impacts from the Program would be temporary, lasting only a brief period of time at any given location, after which time the noise would cease. Thus, the potential for cumulative impacts is low, and any impacts that could occur would be of short duration and less than significant. The incremental noise impacts from any of the Program alternatives, individually or in combination for the entire Program, would not be cumulatively considerable and would not trigger cumulative noise impacts in a given area.

13.11 Summary of Cumulative Impacts

None of the Program alternatives would have incremental impacts that would be cumulatively considerable. The cumulative impacts by resource or environmental topic are summarized as follows:

> Urban and Rural Land Uses: No cumulative significant impacts to urban and rural land uses are anticipated when all of the Program's incremental impacts and the impacts of other activities in the region are considered together.

> Biological Resources – Aquatic: All of the Program alternatives have a less-than-significant cumulative impact on POD. All of the Program alternatives have a less-than-significant cumulative impact on salmonid population trends. The Program would have a less-than-significant cumulative impact on the amount or quality of aquatic habitat from the Physical Control Alternative. The District's incremental activities associated with the control of invasive weeds under the Vegetation Management Alternative would not be cumulatively considerable,

> Biological Resources – Terrestrial: The District's Proposed Program using all of the alternatives does not contribute substantially to pesticide and herbicide exposures in the terrestrial environment. The Chemical Control and Vegetation Management Alternatives have a less-than-significant cumulative impact on terrestrial resource exposures to herbicides and pesticides. The Program's incremental less-than-significant effects relating to weed abatement activities would not, when considered with other weed abatement activities in the Program Area, be cumulatively considerable or significant.

> Ecological Health: While the overall use of pesticides throughout the Program Area may be considered cumulatively significant for nontarget ecological receptors including honeybees, the District's incremental contributions to this impact are not cumulatively significant. Therefore, the Program's long-term activities including chemical applications would not contribute considerably to ecological health impacts.

> Human Health: While the overall use of pesticides throughout the Program Area may be considered cumulatively significant, the District's incremental contributions to this impact are not cumulatively significant. Therefore, the Program's long-term activities including chemical applications would not contribute considerably to human health impacts.

> Public Services and Hazard Response: The Proposed Program does not have incremental impacts on public services, and implementation of any of the Program alternatives (individually or in combination) would not result in a significant contribution to any cumulative public services and hazard response impacts that could result from other projects in the vicinity of the treatment areas

> Water Resources: Where receiving waters have been designated as impaired for pesticides used under the District's IVMP, a cumulatively considerable impact results from all uses of these pesticides or the receiving waters would not be designated as impaired. The District's use of these "impairment chemicals" is contributing in less-than-significant amounts to an existing cumulatively considerable impact in the Program Area and this use is not cumulatively considerable.

> Air Quality: All of the Program alternative emissions (separately and combined for the District's entire Program) would be below the significance thresholds for criteria pollutant emissions. The incremental impacts on air quality from the Program alternatives are not individually significant nor are they cumulatively considerable.

> Climate Change: When all Program emissions are viewed in combination with global emission levels that are contributing to the existing cumulative impact on global climate change, the incremental contribution of these Program emissions would not be cumulatively considerable because they occur intermittently on a very small scale (i.e., not stationary sources).

> Noise: Any impacts that could occur would be of short duration and less than significant. The incremental noise impacts from any of the Program alternatives would not be cumulatively considerable and would not trigger cumulative noise impacts.

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14 Other Required Disclosures

This section addresses other potential impacts as required by CEQA: significant environmental impacts that cannot be avoided if the Proposed Program is implemented, significant irreversible environmental changes that would be caused by the Proposed Program should it be implemented, and growth-inducing impacts of the Proposed Program (see CEQA Guidelines Section 15126.2).

14.1 Significant Unavoidable Impacts

Unavoidable impacts are those adverse environmental consequences of an action that cannot be avoided, either by changing the nature of the action or through mitigation if the action is undertaken.

None of the Program alternatives would result in potentially significant impacts to any resources that could not be reduced to less than significant with the implementation of mitigation measures, (i.e., going beyond the BMPs already in place).

14.2 Irreversible and Irretrievable Commitments of Resources

Irreversible commitments are those that cause either directly or indirectly the use of natural resources to the extent that they cannot be restored or returned to their original condition, including nonrenewable resources. Irreversible decisions can also affect renewable resources such as soils, wetlands, and waterfowl habitats. They are considered irreversible because their implementation would affect a resource that has deteriorated such that renewal takes extensive time or financial resources or because they would destroy a resource.

Irretrievable commitments of natural resources mean the decision would result in loss of production or use of the resources. They represent opportunities foregone for a substantial period of time that the resources cannot be used. Also, irreversible damage can result from environmental accidents associated with a project.

No irreversible or irretrievable commitments of land resources are associated with any of the Program alternatives. For the Program alternatives, potential irreversible and irretrievable impacts are associated with the consumption of energy resources by equipment and vehicles including ATVs and helicopters/aircraft, and the potential for environmental accidents associated with the application equipment and vehicles/aircraft.

14.2.1 Energy Resources

Energy resources necessary for this Program would include gasoline and diesel fuel to power the vehicles and equipment at present and proposed for use in the District's mosquito and/or vector control activities. Equipment use for each of the six Program alternatives is shown in Table 2-7. The No Program Alternative would result in lower use of energy resources (than the Program alternatives), because the fuel currently used in District vehicles for measures such as surveillance and inspection activities, physical control of habitat, vegetation management, and application of registered chemical treatments would not be used.

14.2.2 Environmental Accidents

The following environmental accidents could occur as a result of the implementation of Program surveillance, control, and pesticide/herbicide applications:

> Aircraft crash

> Vehicle crash including fuel spill

> Misdirected spray from backpacks and truck-mounted equipment

> Leakage of chemical pesticides from containers/improper disposal of containers

Chapter 8, *Public Services and Hazard Response*, addresses fixed-wing aircraft/helicopter crashes, and determines that none of the Program alternatives would increase the risk of aircraft crashes. Chapter 8 also analyzes whether the Program would create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment, and determines that no increased risk of fuel spill would occur. Finally, Chapter 8 indicates that under each of the Program alternatives, the District and its registered contractors would practice safe disposal of pesticide products and that properly rinsed empty containers would safely and legally be disposed of at landfills and any unused portions of Program chemicals would be disposed of at permitted hazardous waste collection locations. Adequate landfill and hazardous waste collection capacity exists in locations throughout the Program Area and, therefore, the Program would not exceed the existing capacity to safely dispose of these materials.

14.3 Growth-Inducing Impacts

CEQA Section 21100(b)(5) requires that an EIR discuss the growth-inducing impacts of a proposed project. This requirement is further explained in CEQA Guidelines Section 15126.2 (g), which states that an EIR must address “the ways in which the proposed project could foster economic or population growth, or the construction of additional housing, either directly or indirectly in the surrounding environment.”

The Program alternatives do not foster economic or population growth. Rather, they allow for communities within the Program Area to grow according to local general plans without local residents, workers, and visitors suffering from a variety of illnesses or discomfort from vector-borne diseases. Of concern are areas where human habitations are in close proximity to natural habitats providing ample opportunity for breeding populations of vectors or where home or business maintenance practices encourage vectors to breed. The District would continue its IVMP, and no change in area wide economic activity would occur. Therefore, the Program would not directly or indirectly stimulate economic or population growth and would not induce additional jobs or population in the Program Area.

14.4 Energy Requirements and Conservation Measures

Energy resources necessary for this Program would include gasoline and diesel fuel to power the vehicles, aircraft, and equipment proposed for use in the Program activities. No additional electrical power would be required. All equipment used in Program implementation would be kept up to date with maintenance requirements and would be used as efficiently as possible, i.e., minimize idling time of all vehicles and equipment; service and maintain all equipment according to manufacturer’s instructions to remain in good working order; maintain vehicle tire pressure to manufacturer specifications; and inspect and reinflate tires at regular intervals, as stated in BMP A14 in Table 2-6.

The District would be encouraged to implement the following measures to maximize energy efficiency and reduce energy consumption during Program implementation. With regard to employee commuting, the District is encouraged to (1) provide storage and parking facilities for bicycles; (2) subsidize costs for

workers to take public transportation or participate in ride sharing programs where available; and (3) offer preferential parking for electric, hybrid, or alternative low-carbon fuel vehicles.

With regard to vehicles associated with Program surveillance, control, and treatment activities, the District is encouraged to (1) use lower-carbon fuels such as biodiesel blends where feasible; (2) encourage ride sharing when transporting work crews from the base operations to the job site; and (3) use engine retrofits such as diesel particulate matter filters with diesel oxidation catalysts where feasible.

With regard to portable offroad sources, the District is encouraged to utilize electrically or manually powered hydraulic spray equipment rather than gas- or diesel-powered equipment. Some of the application equipment in use at present is electric.

These energy conservation measures would have the benefit of reducing GHG emissions the Program generates. All impacts to climate change from GHG emissions are less than significant (LS) compared to existing conditions and require no mitigation. As an option, the District may choose to reduce small impacts even further with the following measure: Where practicable and available, the Program will use alternatively fueled equipment, such as compressed natural gas (CNG), liquefied natural gas (LNG), liquefied petroleum/propane gas (LPG), or biodiesel. The District and its contractors may implement the BMPs identified above as applicable to minimize diesel and gasoline engine exhaust emissions.

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15 Alternatives

CEQA Guidelines Section 15126.6(a) requires that a draft EIR must describe a reasonable range of alternatives to the project or project location that could feasibly attain most of the basic project objectives and would avoid or substantially lessen any of the significant environmental impacts of the proposed project. This chapter summarizes the analysis of alternatives for the Marin/Sonoma Mosquito and Vector Control District's IVMP. It is based on Appendix E, *Alternatives Analysis Report* prepared by the District.

15.1 Alternatives Analysis and Screening Process

The District undertakes mosquito and/or vector control activities through its Program to control the following vectors of disease and/ or discomfort in the Program Area: mosquitoes, rats, mice, ticks, and yellow jacket wasps, The District also performs vegetation management activities focused on vegetation that supports mosquito breeding habitat but may include removal of noxious/invasive weeds for other agencies under their permits.

The Proposed Program's specific objectives are as follows:

> Reduce the potential for human and animal disease caused by vectors

> Reduce the potential for human and animal discomfort or injury from vectors

> Accomplish effective and environmentally sound vector management by means of:

  - Surveying for vector abundance/human contact
  - Establishing treatment guidelines
  - Appropriately selecting from a wide range of Program tools or components

The District has a well-defined process for selecting tools to be used in mosquito and/or vector control. The District has evaluated a variety of tools for their effectiveness in meeting the objectives listed above. The criteria used for determining the feasibility or viability and ranking of reasonable tools are listed below:

> **Criterion 1.** The District uses tools known to be effective to manage vector species on a widespread level that have developed breeding populations in the State.

> **Criterion 2.** The District does not use experimental or hypothetically effective tools on a broad scale (but does engage in trial applications with newly developed/released products).

> **Criterion 3.** Given equal efficacy and operational constraints, the District will use the least environmentally disruptive tool in its control Program.

15.2 Alternatives Considered but Eliminated

CEQA Guidelines Section 15126.6(c) requires that the draft EIR explain briefly why other alternatives were rejected. Appendix E describes the tools that were considered and then, subsequently, eliminated from further consideration for inclusion in the Proposed Program. Further analysis of one attract-and-kill formulation, the new AllClear ATSB, is needed prior to using it for mosquito control. Further analysis of the other forms of attract-and-kill and of regulatory control was deemed unnecessary.

The District determined that of the 20 potential tools from Table 3-1 (Appendix E), the following eight methods were not immediately available for use in its IVMP: biological control pathogens (viruses), biological control (parasites), mass trapping, attract and kill, inundative releases (both parasites and predators), regulatory control, and repellents.

> Biological Control pathogens (viruses) are deemed infeasible as this method is not commercially available in California and there are currently many efficacy related issues.

> Biological Control (parasites) is deemed infeasible, as this method is not commercially available in California. Research on the use of parasites for mosquito control has also shown several limitations related to efficacy.

> Mass Trapping is not considered by the District to be a practical, effective, reliable method of controlling vector populations. Can be very expensive and time consuming (i.e., labor intensive).

> Attract and Kill is not considered by the District to be a practical, effective, reliable, method of controlling vector populations. The technology for both mosquitoes and yellow jackets is limited, and effectiveness is either not obtained or is inconsistent. Nontarget insects can be impacted. The District is aware of one commercially available ATSB product, Terminix® AllClear. The District still needs to operationally test this material, as well as other potential ATSBs, to determine those circumstances where their use may be effective while also having little or no nontarget species impacts.

> Inundative Releases of parasites is not considered by the District to be a practical or currently feasible method of controlling vector populations. They are not commercially available and remain experimental at this time.

> Inundative Releases of predators, either sterilized or genetically altered organisms, is not considered by the District to be a practical or a currently feasible method of controlling vector populations. Genetically modified vectors are still experimental. They are also not commercially available at this time.

> Regulatory Control is not considered feasible because adoption of regulations is lengthy, time intensive, expensive and uncertain as to the regulatory outcome. This approach is not focused sufficiently on control of existing populations. Moreover, regulatory controls are dependent upon state and federal agencies to initiate and implement, and thus this approach cannot assure that any project objectives would be achieved.

> Repellants, although effective for small-scale use by humans and animals, are not part of the overall Program control strategy because they merely displace the problem and do not reduce the mosquito population in an area.

15.3 No Program

CEQA Guidelines Section 15126.6(a) requires analysis of a no project alternative in the draft EIR. No Project is defined as what would reasonably be expected to occur in the foreseeable future, based on current plans and consistent with available infrastructure and community services, if the project was not approved and implemented. For the District, the Proposed Program is to continue current nonchemical and chemical treatment activities and to introduce similar pesticides to those currently in use if needed. The No Project/No Program condition assumes that the current activities would cease and result in a “do nothing” alternative going forward. Key assumptions for the future No Program Alternative are:

> Current regulatory controls would continue and expand as needed; however, the District would not engage in implementing any of these regulations concerning public health and management of vectors carrying potential diseases. For all practical purposes, the District’s office would close. Public education and other outreach activities would cease along with the control activities.

> Private landowners would manage mosquito and/.or vector problems on private land without any state or federal oversight with pesticides approved for use. Households would use pesticides commonly available from retail outlets where permethrin and pyrethroids are common ingredients.

> In the absence of the District’s IVMP, the responsibility for vector management could fall on CDPH (or some other agency), who would not provide mosquito and vector control support or “oversight” to local

jurisdictions (from Sacramento) given lack of personnel, equipment, or funding. Management at the state level would likely be only reactive rather than proactive.

The District would perform no surveillance, physical control, vegetation management, biological control, chemical control or other nonchemical control activities within its Service Area or in adjacent jurisdictions. "Do nothing" means the District would cease to exist and not provide the services funded by local property taxes. It is assumed that CDPH would not be able to provide even limited vector management services at the local level. As a result, the vectors of human and animal disease and discomfort would be more numerous than under existing conditions, and proliferate such that outbreaks of disease and illness would occur more frequently. See Appendix E, (Section 4.2) for a more extensive discussion of No Program than presented herein with historical information. In comparison to existing conditions with the current Program fully implemented, the No Program Alternative would have the following environmental impacts:

> Urban and Rural Land Uses: No conflicts with local land regulations and no disruption to recreationists from temporary closures of trails or other park features would occur during chemical treatments. However, the increase in mosquitoes and other vectors would impact the quality of the recreational experience and homeowners due to an increase in discomfort and injury from biting mosquitoes and stinging insects. Stinging insects can cause severe allergic reactions in sensitive individuals, leading to hospitalization and even death. Without control of saltmarsh mosquitoes, all land uses could be affected in nearby areas. Residents could also experience an increase in rats at their homes and businesses. These impacts are **potentially significant**.

> Biological Resources – Aquatic: In the absence of surveillance and physical controls, including maintenance activities within tidal, managed tidal, and nontidal marshes, seasonal wetlands, diked, historic baylands, and in some creeks adjacent to these wetlands, no impact (rather than less-than-significant impacts) would occur to aquatic special-status species using those habitats if present. No conflicts with existing provisions of an HCP/NCCP would occur. It is assumed CDPH would not be able to employ chemical treatments to the same extent as the District. However, lack of IPM-based larval surveillance and control may lead to increased, non-IPM based use of adulticides by individuals and private contractors that could affect aquatic habitats. Ad-hoc larviciding by individuals using unregistered materials (e.g., bleach, oil) would cause substantial harm to biological resources including aquatic habitats. In short, **potentially significant** impacts to aquatic resources would occur under No Program.

> Biological Resources – Terrestrial: Under No Program, terrestrial resources in general would not be impacted significantly. There would be no potential for disturbance to terrestrial habitats and special-status species. However, in the absence of organized mosquito and vector control, unlicensed individuals may apply over-the-counter pesticides on their own, without training and potentially without adhering to label requirements. Furthermore, wildlife including birds would be subject to greater incidence of disease including WNV. The overall impact is **potentially significant** especially if special-status species are affected.

> Ecological Health: Fewer herbicide and pesticide treatments by organized mosquito and vector control agencies would be used to control mosquitoes and other vectors under No Program. Indiscriminant use of aerosol foggers by the public may lead to increased pesticide resistance issues. In the absence of physical controls and nonchemical vegetation management, it is possible that the habitat conditions would result in greater rates of infection of species involved in the transmission of pathogens. Domesticated animals, wildlife, and the public would suffer greater incidence of disease and discomfort. The potential exists for increased use of inappropriate or unregistered materials such as bleach, oil, gasoline, diesel fuel, etc., in an effort to deal with vectors, especially mosquitoes and yellow jackets. Their use can cause significant environmental harm compared to materials applied in accordance with label requirements by trained, licensed professionals. Greater incidence of diseases and possible pesticide resistance would be **potentially significant** impacts.

> Human Health: In the absence of the District's IVMP, greater incidence of vector-borne disease and discomfort to people would occur in the Program Area. A wide range of public health issues would occur with the No Program Alternative,

  - First, risk of human cases of vector-borne disease and vector interaction issues for humans, pets, and wildlife would increase. The San Francisco Bay Area has a well-documented history concerning human-vector interaction, especially with mosquitoes.
  - Second, the lack of any form of coordinated surveillance reduces the ability of any agency to perform disease risk assessments and, therefore, predict potential outbreaks. Although vector-borne disease is not as prevalent as in other areas of the world, vector-borne pathogens are still present.
  - Third, lack of coordinated surveillance increases the risk of emerging infectious diseases or vectors going undetected until they have become established.
  - Fourth, lack of public outreach results in less current information being available about vectors and vector-borne disease risk reduction. This lack of interaction with the public can lead to increased production of vectors on private property as well as increased cases of vector-borne disease in humans, their pets, and livestock. Additionally, the increase in vector-human interactions would result in an increased risk of severe reactions to the bites and stings of vector organisms (e.g., mosquitoes, ticks, and yellow jackets) in sensitive and immunocompromised individuals.
  - Fifth, in the absence of organized mosquito and vector control programs, unlicensed individuals could begin applying over-the-counter pesticides on their own. Most of these individuals have little or no training in the proper and effective use of these materials, meaning a reasonable possibility exists of over- or under-application as well as the potential for creation of unrecognized resistance issues. This possibility is especially true for the indiscriminate use of aerosol foggers as well as concentrated pesticides that require mixing with water prior to application. Additionally, the health and well-being of sensitive individuals (e.g., asthmatics and chemically sensitive people) and their pets (especially birds and fish) could be affected by the unexpected drift of these pesticides into their yards, open windows, and neighborhood parks from attempts by unlicensed individuals using pesticides. Increased pesticide use by unlicensed individuals outside of an IPM program could potentially impact water resources and human and ecological health.

  CDPH would not be able to replace all of the services the District currently provides or would provide under the Proposed Program. Lack of coordinated surveillance increases risk of emerging diseases or vectors going undetected until already established in an area; it reduces disease risk assessments an outbreak predictions at the local level. Lack of public outreach leads to increased mosquito production on private property and less information being available to people about vector-borne disease reduction. Homeowners would resort to use of pesticides available to them, many of which are more toxic than the ones used by the District. This impact on human health is **potentially significant**.

> Public Services and Hazard Response: The greater use of over-the-counter pesticides could lead to greater improper disposal of the containers. There could also be a greater demand on emergency services due to improper use of pesticides resulting in accidental poisonings, exposures of asthmatics and chemically sensitive individuals, etc. A greater incidence of disease and discomfort would potentially increase the demand for emergency services in the Program Area, a **potentially significant** impact.

> Water Resources: Under No Program, use of chemical treatments would be reduced compared to existing conditions. **No impact** on surface and groundwater resources would occur.

> Air Quality: The District would cease vector control activities, resulting in no use of vehicles, equipment, or pesticides and herbicides. **No impact** on air quality would occur.

> Greenhouse Gases and Climate Change: The District would cease vector control activities, resulting in no use of vehicles, equipment, or pesticides and herbicides. However, increased mosquito populations may lead to reduced outdoor recreation, especially non-motorized recreation such as hiking and bicycling, and increased indoor recreation involving greater electricity usage for air conditioning and entertainment. A **less-than-significant** impact on GHG emissions would occur.

> Noise: The District would cease vector control activities, resulting in no use of vehicles, equipment, or pesticides and herbicides. **No impact** on noise would occur.

> Economic Conditions: A number of economic issues are associated with the No Program Alternative. Appendix E cites several sources of information on the cost of not having effective vector control in an area with key findings presented below:

- First, with increased human-vector interactions comes an increase in the number of cases of vector-borne disease. The short-term medical and lost workplace, school, and home time associated with illness can cost governments, businesses, families, and individuals upwards of many thousands of dollars.
- Second, increased vector populations can lead to reduced outdoor recreation activities by the public, resulting in increased usage of electricity for air conditioning and indoor entertainment. These increases could also lead to a reduction in revenues for recreational areas such as parks, campgrounds, marinas, and other areas that depend on usage fees to help with their maintenance and staffing, not to mention the impacts on other aspects of tourism (food, lodging, gear purchases, and equipment rentals).
- Third, increased vector populations not only lead to increased levels of vector-borne disease and discomfort but can also result in decreased property values. Property values form an essential part of the revenue stream for government services such as schools, police, fire, libraries, parks, and health and welfare programs.
- Fourth, the cost of hiring private contractors to provide vector control services on a site-specific basis can end up being more costly than the costs associated with the current program (with economies of scale).

15.4 Alternatives to Reduce Significant Impacts

CEQA Guidelines Section 15126.6(b) also requires that a draft EIR identify alternatives that are capable of avoiding or substantially lessening the significant environmental effects of the proposed project, even if the alternative would impede to some degree the attainment of all of the project objectives or would be more costly.

One potentially significant impact is associated with the Proposed Program, an air quality impact associated with the Chemical Control Alternative. The Chemical Control Alternative could subject people to objectionable odors. Impacts even with BMPs implemented could be **potentially significant but mitigable** (Impact AQ-25)**.** Certain VOCs, sulfur compounds, and chlorine compounds found in some pesticides emit characteristic odors when they evaporate (volatilize) into air, even at very low concentrations well within safety limits. Pesticides currently used or proposed for future use emit phenols (e.g., deltamethrin, etofenprox, permethrin, or resmethrin). Materials such as Bti in liquid form and the adulticides pyrethrin and permethrin have an odor. Due to the low application rates of these materials, mixing with water (e.g., liquid Bti) and the ULV application method (e.g., for adulticides), relatively small quantities of these types of materials are typically used at a given time. Nevertheless, the human sense of smell (olfactory system) is sensitive to these types of compounds as a warning mechanism, and some individuals are more sensitive than others. The Chemical Control Alternative as proposed would apply certain types of odorous treatments using hydraulic spraying and atomizing (fogging), which could result in drift of small droplets and gaseous vapors. Depending on atmospheric conditions (i.e., wind direction, wind

speed, stability class), this drift could subject people to objectionable odors near a treatment area. Without site-specific information, it cannot be determined whether an objectionable odor may persist downwind of a particular treatment area; therefore, an application containing an odorous compound may impact an undefined number people for an undefined period of time. The materials have been used in the current Program, and people have not complained about odors. However, it is possible that complaints could occur in the future despite public notification procedures about large-scale treatments.

Modifications to the Proposed Program could include the following reduced Program based on a "Reduced Chemical Control Alternative" which would avoid the potentially significant impact associated with the Proposed Program. A reduced Program with a "No Chemical Control Alternative" is evaluated as well.

15.4.1 Reduced Chemical Control Alternative Program

This alternative would eliminate or limit the use of any of the options of using odorous pesticide products containing phenols (e.g., deltamethrin, etofenprox, permethrin, or resmethrin), certain formulations of the larvicide Bti (e.g., liquid), and pyrethrin and permethrin as mosquito adulticides and for control of yellow jacket wasps and ticks in populated areas or in areas used for outdoor recreation. Yellow jacket control is only provided in areas where people or domestic animals could be injured. However, materials such as pyrethrin and others using hand held or ATV mounted equipment are most often used in remote areas away from residences and local parks. They are small scale, site-specific applications, and/or not conducted in the immediate vicinity of the public, and/or arrangements are made to perform the application when the public is not present. The odors these materials produce are also very short lived.

This Reduced Chemical Control Program would include all of the Surveillance, Physical Control, Vegetation Management, and other Nonchemical Control/Trapping Alternatives as planned under the Proposed Program but would eliminate or limit the options under the Chemical Control Alternative of using one or more of the pesticides with the greatest potential to subject people to objectionable odors: pyrethrin, permethrin, resmethrin, deltamethrin, etofenprox and some formulations of Bti (liquid) for control of mosquitoes and for control of yellow jacket wasps. It could result in greater use of other, less malodorous chemicals and in greater amounts, which could have impacts on public health if these other chemical methods are not as effective for the specific treatment area due to vector resistance problems or specific site conditions (see No Chemical Alternative below). All of these odorous pesticides can be used without significant impacts to public health or to other air quality parameters; but where people are located close to or possibly recreate within a chemical treatment area, the odor could be a problem for some persons even when the application is within product label specifications for wind speed and consistent with District BMPs.

The Reduced Chemical Control Program could be implemented consistent with the Program objectives on a situational or case-by-case basis (e.g., adult mosquito control is not required or a liquid formulation of Bti is not required) as long as the area affected is not large scale (i.e., relatively small number of specific individual sites as compared to an areawide basis) and as long as other, less odorous chemical options at comparable costs are available for use, the vector is not resistant to the remaining chemical options, and the remaining options have a high probability of being effective. Limiting the choices of materials that can be used to a few chemicals significantly increases the risks of vector resistance to the few products that are available for use. Furthermore, certain formulations may not be compatible with certain sites (e.g., crops and agricultural lands). Typically, the odorous chemicals (pyrethrin, permethrin, resmethrin, etofenprox) are used for adult mosquito control, thus eliminating the ability to control the adult, disease-transmitting life stage of the mosquito or yellow jacket and, therefore, resulting in ineffective and problematic vector control and increased public health risk. Removing the types of pesticides listed above from the IVMP entirely or even on a relatively large scale (i.e., beyond a situational/individual/case-by-case site basis) would reduce Program effectiveness and not meet Program objectives. Sound IVM involves many tools, with many materials being used, and using the most effective and least environmentally harmful products.

For the other environmental resources and issues of land use, biological, ecological health, human health, public services, water quality, air quality, GHGs, and noise, the impacts of the Reduced Chemical Control Program would be "no impact" or "less-than-significant impact," consistent with the environmental impact evaluations provided in Chapters 3 through 12 for the Surveillance, Physical Control, Vegetation Management, Chemical Control, and Other Nonchemical Control/Trapping Alternatives if Program effectiveness was not affected. See Table 15-1 for the specific impact statements by resource topic/issue for all of these Program alternatives, which would be applicable to a Reduced Chemical Control Program with the exception of Impact AQ-25 which would be less than significant. However, if the less malodorous pesticides are relied upon and result in a less effective Program due to vector resistance issues, then the public and ecological health impacts from a less effective Program would be a greater incidence of vector-borne disease and discomfort to people, animals, and birds in the Program Area than under the Proposed Program but not as much as would occur under No Program or the reduced Program with a No Chemical Control Alternative.

15.4.2 No Chemical Control Program

This reduced Program would exclude all of the pesticide and herbicide products associated with the Chemical Control and Vegetation Management Alternatives under the Proposed Program. It would rely solely on Surveillance, Physical Control, the nonchemical physical component of Vegetation Management, Biological Control (mosquitofish), and the Other Nonchemical Control/Trapping Alternatives, along with ongoing public education. The issue is whether a Program made up only of these remaining alternatives plus education would be effective and meet Program objectives and IVM principles.

An example of reliance on only nonchemical tools with public education is the approach the State of Texas took in 2012 to deal with a WNV outbreak.

> In Summer 2012, the Dallas-Fort Worth Metroplex experienced a severe WNV outbreak in which more than 1,868 confirmed cases of West Nile disease and 89 WNV-related deaths were reported. The analysis of mitigation efforts for the WNV outbreak in Texas suggested two lessons for improving public health system in preparation for future events: the need for (1) clear, comprehensive, uniform data systems that include mosquito data and (2) science-based triggers for spraying, as well as mutual assistance plans with spraying companies and among jurisdictions for times when spraying is necessary. (Harris County Public Health & Environmental Services 2012)

> Spraying larvicides and/or adulticides for mosquitoes was not part of Texas' routine protocol. Texas had not sprayed for mosquitoes in 43 years before the WNV outbreak. The WNV outbreak in Texas demonstrated the capacity for an epidemic to spread from one state to the entire country. Once the spraying was completed (two applications), a 93 percent reduction in disease-carrying mosquitoes occurred, while areas that were not sprayed reported an increase. (Zhang 2012)

> In 2010, 2011, and 2012, Dallas County's health department did not purchase mosquito larvicides until July 30, 2012, following the CDC telling the department that Dallas was already at the highest possible risk level for WNV. To avoid outbreaks such as what occurred in Dallas, aggressive larviciding is an effective tool along with surveillance of dead birds. (Friedman 2012)

Bandon Marsh National Wildlife Refuge (889 acres) protects the largest remaining tidal salt marsh within the Coquille River estuary in Oregon. The USFWS had restored an old hayfield back to tidal marsh by September 2011, with resultant mosquito production that resulted in an angry public with the mayor and a congressman getting involved. The USFWS now sprays for mosquitoes using larvicides Bti, methoprene and oil as a last resort.

These reports and others indicate that chemical control was required to combat an outbreak of mosquitoes (Oregon) and mosquitoes infected with WNV (Texas). Not letting mosquito populations get out of control due to inadequate surveillance and control measures is critical to avoidance of a large outbreak such as the one experienced in Texas in 2012. Consequently, a No Chemical Control

Alternative would not be effective and not meet the District's Proposed Program objectives stated in Section 2.2.2. The No Chemical Control Alternative would not meet the principles of successful IVM. The impacts to public health would be as follows:

> **Human Health:** In the absence of the chemical control tools being included in the District's IVMP, greater incidence of vector-borne disease and discomfort to people would occur in the Program Area. A wide range of public health issues would occur with the No Chemical Control Alternative:

  - First, risk of human cases of vector-borne disease and vector interaction issues for humans, pets, and wildlife would increase. The San Francisco Bay Area has a well-documented history concerning human-vector interaction, especially with mosquitoes.
  - Second, increased production of vectors would occur on private property adjacent to areas that previously were treated with pesticide (and herbicide) products as well as increased cases of vector-borne disease in humans, their pets, and livestock would. Additionally, the increase in vector-human interactions would result in an increased risk of severe reactions to the bites and stings of vector organisms (e.g., mosquitoes, ticks, and wasps) in sensitive and immunocompromised individuals.
  - Third, in the absence of organized mosquito and vector control programs using chemical controls and reduced effectiveness in controlling vectors, unlicensed individuals could begin applying over-the-counter pesticides on their own. Most of these individuals have little or no training in the proper and effective use of these materials, meaning a reasonable possibility exists of over- or under-application as well as the potential for creation of unrecognized resistance issues. This possibility is especially true for the indiscriminate use of aerosol foggers as well as concentrated pesticides that require mixing with water prior to application. Additionally, the health and well-being of sensitive individuals (e.g., asthmatics and chemically sensitive people) and their pets (especially birds and fish) could be affected by the unexpected drift of these pesticides into their yards, open windows, and neighborhood parks.

  This impact on human health is **significant and unavoidable**.

For the other land use, biological, ecological health, public services, water quality, air quality, GHGs, and noise environmental resources and issues, the impacts of the No Chemical Control Program would be "no impact" or "less-than-significant impact," similar to the environmental impact evaluations provided in Chapters 3 through 12 for the Surveillance, Physical Control, Vegetation Management (physical control option only), and Other Nonchemical Control/ Trapping Alternatives. See Table 15-1 for the specific impact statements by resource topic/issue for all of these Program alternatives which would be applicable to a No Chemical Control Program. However, the indiscriminate use of over-the-counter pesticides and improper disposal has the potential to adversely affect ecological health. If homeowners apply the products consistent with label requirements, potentially significant impacts would be avoided.

15.5 Comparison of Alternatives

Table 15-1 presents a summary of all of the impacts associated with each Program Alternative and, therefore, the overall Proposed Program of all of the alternatives combined. The potential for objectionable odors to people under the Chemical Control Alternative is the only situation where potentially significant impacts could occur.

> The Surveillance Alternative has the potential for less-than-significant impacts to recreational land uses, biological resources (aquatic and terrestrial), ecological health, air quality, GHGs, and noise. It has no impacts to land use regulations, human health, public services/hazard response, and water resources.

> The Physical Control Alternative has the potential for less-than-significant impacts to recreational land uses, biological resources (aquatic and terrestrial), ecological health, human health, water resources, air quality, GHGs, and noise. It has no impacts to land use regulations and public services/hazard response.

> The Vegetation Management Alternative has the potential for less-than-significant impacts to recreational land uses, aquatic and terrestrial biological resources, ecological health, human health, water resources, air quality, GHGs, and noise. It would have no impact to land use regulations and public services/hazard response.

> The Biological Control Alternative has the potential for less-than-significant impacts to ecological health, water resources, air quality, GHGs, and noise. It has no impacts to land use, biological resources (aquatic and terrestrial), human health, public services/hazard response.

> The Chemical Control Alternative has less-than-significant impacts to recreational land uses, aquatic and terrestrial biological resources, ecological health, human health, surface and groundwater resources, GHGs, and noise. It has no impacts to land use regulations and public services/hazard response. The potential exists for subjecting people to objectionable odors depending on the formulation used and proximity of treatment locations to human activities, a significant impact that can be mitigated to less than significant.

> The Other Nonchemical/Trapping Alternative has less-than-significant impacts to the following resources and issues: recreational land uses, air quality, GHGs, and noise. It has no impacts to land use regulations, biological resources (aquatic and terrestrial), ecological health, human health, public services/hazard response, and water resources.

Table 15-2 provides a comparison of the Proposed Program, Reduced Chemical Control Program, and No Chemical Control Program.

15.6 Environmentally Superior Alternative

As shown in Table 15-1, for Surveillance, Physical Control, Vegetation Management, Chemical Control, and Nonchemical Control/Trapping Alternatives, the impacts are either “less than significant” (LS) or “no impact” (N) with one “potentially significant but mitigable impact” (SM).

The Chemical Control Alternative could subject people to objectionable odors. Impacts even with BMPs implemented could be **potentially significant but mitigable.** Certain VOCs, sulfur compounds, and chlorine compounds found in some pesticides emit characteristic odors when they evaporate (volatilize) into air, even at very low concentrations well within safety limits. Pesticides currently used or proposed for future use emit phenols (e.g., deltamethrin, etofenprox, permethrin, or resmethrin). Materials such as Bti in liquid form and the adulticides pyrethrin and permethrin have an odor. Due to limited applicability, small quantities of these types of substances are typically used. The human sense of smell (olfactory system) is sensitive to these types of compounds as a warning mechanism, and some individuals are more sensitive than others. The Chemical Control Alternative would apply certain types of odorous treatments using hydraulic spraying and atomizing (fogging), which could result in drift of small droplets and gaseous vapors. Depending on atmospheric conditions (i.e., wind direction, wind speed, stability class), this drift could subject people to objectionable odors near a treatment area. The materials have been used in the current Program, and people have not complained about odors. However, it is possible that complaints could occur in the future despite public notification procedures about large-scale treatments.

Section 15.4 describes two "Reduced Program Alternatives:" Reduced Chemical Control and No Chemical Control.

> Reduced Chemical Control: To the extent the District can modify elements of the Chemical Control Alternative to mitigate identified impacts by avoiding the potentially significant impacts associated with some pesticide products by using less of any of these products or by eliminating one or more them in favor of other, less odorous products, then the **environmentally superior alternative would be a**

Program incorporating these modifications to this alternative as components of the overall IVMP as long as Program effectiveness is maintained. Excluding air quality and the odor issue, the impacts to all of the other resources would be the same as for the Proposed Program.

> No Chemical Control: This alternative would completely remove the chemical treatment options under the Vegetation Management and Chemical Control Alternatives. It would not have any of the less-than-significant impacts associated with herbicide and pesticide use. However, it was determined to be inconsistent with Program objectives and IVM principles, and it could lead to substantial impacts to human health due to the reduced effectiveness of the Program in controlling mosquito and other vector populations.

The No Program Alternative is not the environmentally superior alternative due to its potentially significant impacts to the following resources and concerns identified in Section 15.3: urban and rural land uses, aquatic and terrestrial biological resources, ecological health, human health, and public services and hazard response.

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
3. Urban and Rural Land Uses						
Impact LU-1: Surveillance of vectors would not appreciably impact the quantity and/or quality of recreational opportunities in the Program Area. This impact is **less than significant** and no mitigation is required.	LS	na	na	na	na	na
Impact LU-2: Surveillance of vectors would not be inconsistent with applicable land use regulations. **No impact** would occur.	N	na	na	na	na	na
Impact LU-3: Physical control of vector habitat would not appreciably impact the quantity and/or quality of recreational opportunities in the Program Area. This impact is **less than significant** and no mitigation is required.	na	LS	na	na	na	na
Impact LU-4: Physical control of vectors would not be inconsistent with applicable land use regulations. **No impact** would occur.	na	N	na	na	na	na
Impact LU-5: Vegetation management would not appreciably impact the quantity and/or quality of recreational opportunities in the Program Area. This impact is **less than significant** and no mitigation is required.	na	na	LS	na	na	na
Impact LU-6: Vegetation management would not be inconsistent with applicable land use regulations. **No impact** would occur.	na	na	N	na	na	na
Impact LU-7: Biological control of vectors would not appreciably impact the quantity and/or quality of recreational opportunities in the Program Area. **No impact** would occur.	na	na	na	N	na	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact LU-8: Biological control of vectors would not be inconsistent with applicable land use regulations. **No impact** would occur.	na	na	na	N	na	na
Impact LU-9: Chemical application to control vectors would impact recreational access and the quality of recreational opportunities in the Program Area. However, because these impacts would be isolated and short term and would involve public notification for the large events in close proximity to recreation intensive use areas, they are considered **less than significant** and no mitigation is required.	na	na	na	na	LS	na
Impact LU-10: The Chemical Control Alternative would not be inconsistent with applicable land use regulations because state law preempts local ordinances. **No impact** would occur.	na	na	na	na	N	na
Impact LU-11: Trapping of vectors would not appreciably impact the quantity and/or quality of recreational opportunities in the Program Area. This impact is **less than significant** and no mitigation is required.	na	na	na	na	na	LS
Impact LU-12: Other nonchemical control and trapping of vectors would not conflict with applicable land use regulations. **No impact** would occur.	na	na	na	na	na	N
4. Biological Resources – Aquatic						
Impact AR-1. The Surveillance Alternative would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	LS	na	na	na	na	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact AR-2. The Surveillance Alternative would have a **less-than-significant** impact on any riparian habitat or other sensitive natural community No mitigation is required.	LS	na	na	na	na	na
Impact AR-3. The Surveillance Alternative would have a **less-than-significant** impact on federally protected wetlands as defined by Section 404 of the Clean Water Act. No mitigation is required.	LS	na	na	na	na	na
Impact AR-4. The Surveillance Alternative would have **no impact** on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites.	N	na	na	na	na	na
Impact AR-5. The Surveillance Alternative would have **no impact** on local policies or ordinances protecting biological resources.	N	na	na	na	na	na
Impact AR-6. The Surveillance Alternative has a **less-than-significant** impact on any adopted HCPs or NCCPs. No mitigation is required.	LS	na	na	na	na	na
Impact AR-7. The Physical Control Alternative, would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	LS	na	na	na	na
Impact AR-8. The Physical Control Alternative would have a **less-than-significant** impact on any riparian habitat or other sensitive natural community. No mitigation is required.	na	LS	na	na	na	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact AR-9. The Physical Control Alternative would have a **less-than-significant** impact on federally protected wetlands as defined by Section 404 of the Clean Water Act. No mitigation is required.	na	LS	na	na	na	na
Impact AR-10. The Physical Control Alternative would have a **less than significant** impact on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites. No mitigation is required.	na	LS	na	na	na	na
Impact AR-11. The Physical Control Alternative would have **no impact** on local policies or ordinances protecting aquatic resources.	na	N	na	na	na	na
Impact AR-12. The Physical Control Alternative would have a **less-than-significant** impact on adopted HCPs or NCCPs. No mitigation is required.	na	LS	na	na	na	na
Impact AR-13. The Vegetation Management Alternative would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	na	LS	na	na	na
Impact AR-14. The Vegetation Management Alternative would have a **less-than-significant** impact on any riparian habitat or other sensitive natural community. No mitigation is required.	na	na	LS	na	na	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact AR-15. The Vegetation Management Alternative would not result in the direct removal, filling, or hydrological interruption of federally protected wetlands as defined by CWA Section 404. As such, this alternative and would have a have a **less-than-significant** impact on these resources. No mitigation is required.	na	na	LS	na	na	na
Impact AR-16. The Vegetation Management Alternative would have a **less-than-significant** impact on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites. No mitigation is required.	na	na	LS	na	na	na
Impact AR-17. The Vegetation Management Alternative would have **no impact** on local policies or ordinances protecting biological resources.	na	na	N	na	na	na
Impact AR-18. The Vegetation Management Alternative would have a **less-than-significant** impact on adopted HCPs or NCCPs. No mitigation is required.	na	na	LS	na	na	na
Impact AR-19. The Biological Control Alternative would have **no impact** either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species.	na	na	na	N	na	na
Impact AR-20. The Biological Control Alternative would have **no impact** on any riparian habitat or other sensitive natural community.	na	na	na	N	na	na
Impact AR-21. The Biological Control Alternative would have **no impact** on federally protected wetlands as defined by CWA Section 404.	na	na	na	N	na	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact AR-22. The Biological Control Alternative would have **no impact** on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites.	na	na	na	N	na	na
Impact AR-23. The Biological Control Alternative would have **no impact** on local policies or ordinances protecting biological resources.	na	na	na	N	na	na
Impact AR-24. The Biological Control Alternative would have **no impact** on approved HCPs, NCCPs, or local conservation plans.	na	na	na	N	na	na
Impact AR-25: The Chemical Control Alternative's mosquito larvicides would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	na	na	na	LS	na
Impact AR-26: The Chemical Control Alternative's mosquito adulticides would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	na	na	na	LS	na
Impact AR-27. The Chemical Control Alternative's control of yellow jackets and ticks would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special- status species. No mitigation is required.	na	na	na	na	LS	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact AR-28. The Chemical Control Alternative would have **no impact** on any riparian habitat or other sensitive natural community	na	na	na	na	N	na
Impact AR-29. The Chemical Control Alternative would not result in the direct removal, filling, or hydrological interruption of federally protected wetlands as defined by CWA Section 404 and would have a have **no impact** on these resources.	na	na	na	na	N	na
Impact AR-30. The Chemical Control Alternative would have a **less-than-significant** impact on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites. No mitigation is required.	na	na	na	na	LS	na
Impact AR-31. The Chemical Control Alternative would have **no impact** on local policies or ordinances protecting biological resources.	na	na	na	na	N	na
Impact AR-32. The Chemical Control Alternative would have a **less-than-significant** impact on approved HCPs, NCCPs, or local conservation plans. No mitigation is required.	na	na	na	na	LS	na
Impact AR-33. The Other Nonchemical Control/Trapping Alternative would have **no impact** either directly or through habitat modifications, on any aquatic species identified as a candidate, sensitive, or special-status species.	na	na	na	na	na	N
Impact AR-34. The Other Nonchemical Control/Trapping Alternative would have **no impact** on any riparian habitat or other sensitive natural community.	na	na	na	na	na	N

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact AR-35. The Other Nonchemical Control/Trapping Alternative would have **no impact** on federally protected wetlands as defined by CWA Section 404.	na	na	na	na	na	N
Impact AR-36. The Other Nonchemical Control/Trapping Alternative would have **no impact** on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites.	na	na	na	na	na	N
Impact AR-37. The Other Nonchemical Control/Trapping Alternative would have **no impact** on local policies or ordinances protecting biological resources.	na	na	na	na	na	N
Impact AR-38. The Other Nonchemical Control/Trapping Alternative would have **no impact** on approved HCPs, NCCPs, or local conservation plans.	na	na	na	na	na	N
5. Biological Resources – Terrestrial						
Impact TR-1. The Surveillance Alternative would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	LS	na	na	na	na	na
Impact TR-2. The Surveillance Alternative would have a **less-than-significant** impact on riparian habitat or other sensitive natural communities. No mitigation is required.	LS	na	na	na	na	na
Impact TR-3. The Surveillance Alternative would have a **less-than-significant** impact on federally protected wetlands as defined by Section 404 of the Clean Water Act. No mitigation is required.	LS	na	na	na	na	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact TR-4. The Surveillance Alternative would have **no impact** on the movement of any native resident or migratory fish or wildlife species, nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites.	N	na	na	na	na	na
Impact TR-5. The Surveillance Alternative would have **no impact** on local policies or ordinances protecting biological resources.	N	na	na	na	na	na
Impact TR-6. The Surveillance Alternative would have a **less-than-significant** impact on adopted HCPs or NCCPs. No mitigation is required.	LS	na	na	na	na	na
Impact TR-7. The Physical Control Alternative, would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	LS	na	na	na	na
Impact TR-8. The Physical Control Alternative, would have a **less-than-significant** impact on any riparian habitat or other sensitive natural community. No mitigation is required.	na	LS	na	na	na	na
Impact TR-9. The Physical Control Alternative would have a **less-than-significant** impact on federally protected wetlands as defined by CWA Section 404. No mitigation is required.	na	LS	na	na	na	na
Impact TR-10. The Physical Control Alternative would have **a less than significant** impact on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites.	na	LS	na	na	na	na
Impact TR-11. The Physical Control Alternative would have **no impact** on local policies or ordinances protecting terrestrial resources.	na	N	na	na	na	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact TR-12. The Physical Control Alternative would have a **less-than-significant** impact on adopted HCPs or NCCPs. No mitigation is required.	na	LS	na	na	na	na
Impact TR-13. The Vegetation Management Alternative would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	na	LS	na	na	na
Impact TR-14. The Vegetation Management Alternative would have a **less-than-significant** impact on any riparian habitat or other sensitive natural community. No mitigation is required.	na	na	LS	na	na	na
Impact TR-15. The Vegetation Management Alternative would have a **less-than-significant** impact on federally protected wetlands as defined by CWA Section 404. No mitigation is required.	na	na	LS	na	na	na
Impact TR-16. The Vegetation Management Alternative would have a **less-than-significant impact** on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites. No mitigation is required.	na	na	LS	na	na	na
Impact TR-17. The Vegetation Management Alternative would have **no impact** on local policies or ordinances protecting terrestrial resources.	na	na	N	na	na	na
Impact TR-18. The Vegetation Management Alternative has a **less-than-significant** impact on approved HCPs or NCCPs. No mitigation is required.	na	na	LS	na	na	na
Impact TR-19. The Biological Control Alternative would have **no impact** either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species.	na	na	na	N	na	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact TR-20. The Biological Control Alternative would have **no impact** on any riparian habitat or other sensitive natural community.	na	na	na	N	na	na
Impact TR-21. The Biological Control Alternative would have **no impact** on federally protected wetlands as defined by CWA Section 404.	na	na	na	N	na	na
Impact TR-22. The Biological Control Alternative would have **no impact** on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites.	na	na	na	N	na	na
Impact TR-23. The Biological Control Alternative would have **no impact** on local policies or ordinances protecting biological resources.	na	na	na	N	na	na
Impact TR-24. The Biological Control Alternative would have **no impact** on approved HCPs, NCCPs, or local conservation plans.	na	na	na	N	na	na
Impact TR-25: The Chemical Control Alternative's mosquito larvicides would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	na	na	na	LS	na
Impact TR-26: The Chemical Control Alternative's mosquito adulticides would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	na	na	na	LS	na
Impact TR-27: The Chemical Control Alternative's use of the synergist PBO would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	na	na	na	LS	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact TR-28: The Chemical Control Alternative's use of pyrethrin, pyrethroids, and pyrethroid-like pesticides for yellow jacket wasp and tick control would have a **less-than-significant** impact either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	na	na	na	LS	na
Impact TR-29. The Chemical Control Alternative would have **no impact** on any riparian habitat or other sensitive natural community.	na	na	na	na	N	na
Impact TR-30. The Chemical Control Alternative would have **no impact** on federally protected wetlands as defined by CWA Section 404.	na	na	na	na	N	na
Impact TR-31. The Chemical Control Alternative would have a **less-than-significant** impact on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites. No mitigation is required.	na	na	na	na	LS	na
Impact TR-32. The Chemical Control Alternative would have **no impact** on local policies or ordinances protecting terrestrial resources.	na	na	na	na	N	na
Impact TR-33. The Chemical Control Alternative would have a **less-than-significant** impact on approved HCPs, NCCPs, or local conservation plans. No mitigation is required.	na	na	na	na	LS	na
Impact TR-34. The Other Nonchemical Control/Trapping Alternative would have a **less-than-significant** impact either directly or through habitat modifications, on any terrestrial species identified as a candidate, sensitive, or special-status species. No mitigation is required.	na	na	na	na	na	LS
Impact TR-35. The Other Nonchemical Control/Trapping Alternative would have **no impact** on any riparian habitat or other sensitive natural community.	na	na	na	na	na	N

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact TR-36. The Other Nonchemical Control/Trapping Alternative would have **no impact** on federally protected wetlands as defined by CWA Section 404.	na	na	na	na	na	N
Impact TR-37. The Other Nonchemical Control/Trapping Alternative would have **no impact** on the movement of any native resident or migratory fish or wildlife species. Nor would it impact any native resident or migratory wildlife corridors or impede the use of native wildlife nursery sites.	na	na	na	na	na	N
Impact TR-38. The Other Nonchemical Control/Trapping Alternative would have **no impact** on local policies or ordinances protecting terrestrial resources.	na	na	na	na	na	N
Impact TR-391. The Other Nonchemical Control/Trapping Alternative would have **no impact** on approved HCPs, NCCPs, or local conservation plans.	na	na	na	na	na	N
6. Ecological Health						
Impact ECO-1: The Surveillance Alternative would have a **less-than-significant** impact on nontarget ecological receptors, including native or special-status plants and animals and mitigation is not required.	LS	na	na	na	na	na
Impact ECO-2: The Physical Control Alternative would have a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	LS	na	na	na	na
Impact ECO-3: The employment of a nonherbicide Vegetation Management Alternative in the form of physical removal would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	LS	na	na	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact ECO-4: The use of any of the selected herbicides as a vegetation management technique would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	LS	na	na	na
Impact ECO-5: The use of glyphosate would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	LS	na	na	na
Impact ECO-6: The use of adjuvants would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	LS	na	na	na
Impact ECO-7: The use of mosquitofish as a Biological Control Alternative would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	na	LS	na	na
Impact ECO-8: The use of bacterial larvicides would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	na	na	LS	na
Impact ECO-9: The use of methoprene for mosquito larvae would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	na	na	LS	na
Impact ECO-10: The use of surfactants for the control of mosquito larvae would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	na	na	LS	na
Impact ECO-11: The use of pyrethrins for adult mosquitoes and yellow jacket wasps would result in a **less-than-significant** impact to nontarget ecological receptors including aquatic organisms and bees and mitigation is not required.	na	na	na	na	LS	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact ECO-12: The use of pyrethroids and pyrethroid-like compounds (e.g., resmethrin, permethrin, and etofenprox) for mosquitoes and yellow jacket wasps would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	na	na	LS	na
Impact ECO-13: The use of synergists (PBO) for mosquitoes and yellow jacket wasps would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	na	na	LS	na
Impact ECO-14: The use of pyrethroids and pyrethroid-like compounds for yellow jacket wasps and ticks would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	na	na	LS	na
Impact ECO-15: The Other Nonchemical Control/Trapping Alternative would result in a **less-than-significant** impact to nontarget ecological receptors and mitigation is not required.	na	na	na	na	na	LS
7. Human Health						
Impact HH-1: No impact would occur to human health from the use of the Surveillance Alternative.	N	na	na	na	na	na
Impact HH-2: Impacts to human health from use of the Physical Control Alternative would be **less than significant** and mitigation is not required.	na	LS	na	na	na	na
Impact HH-3: No impact would occur to human health from the nonherbicide Vegetation Management Alternative.	na	na	N	na	na	na
Impact HH-4: Impacts to human health from the herbicides imazapyr and triclopyr would be **less than significant** and mitigation is not required.	na	na	LS	na	na	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact HH-5: Impacts to human health from the use of glyphosate would be **less than significant** and mitigation is not required.	na	na	LS	na	na	na
Impact HH-6: Impacts to human health from the use of pesticide adjuvants would be **less than significant** and mitigation is not required.	na	na	LS	na	na	na
Impact HH-7: No impact would occur to human health from the use of mosquitofish.	na	na	na	N	na	na
Impact HH-8a: No impact would occur to human health from the use of bacterial larvicides.	na	na	na	na	N	na
Impact HH-8b: No impact would occur to human health from the use of the mosquito larvicide methoprene.	na	na	na	na	N	na
Impact HH-8c: No impact would occur to human health from the use of surfactant larvicides (alcohol ethoxylated surfactant and aliphatic solvents).	na	na	na	na	N	na
Impact HH-9: Impacts to human health from the use of pyrethrins would be **less than significant** and mitigation is not required.	na	na	na	na	LS	na
Impact HH-10: Impacts to human health from the use of pyrethroids and pyrethroid-like compounds as mosquito adulticides would be **less than significant** and mitigation is not required.	na	na	na	na	LS	na
Impact HH-11: Impacts to human health from the use of the synergist PBO in mosquito adulticides would be **less than significant** and mitigation is not required.	na	na	na	na	LS	na
Impact HH-12: No impact would occur to human health from the District's use of the Other Nonchemical Control/Trapping Alternative.	na	na	na	na	na	N

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
8. Public Services and Hazard Response						
Impact PSH-1: Surveillance activities would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.	N	na	na	na	na	na
Impact PSH-2: Surveillance activities would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.	N	na	na	na	na	na
Impact PSH-3: Surveillance activities would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.	N	na	na	na	na	na
Impact PSH-4: Physical control activities would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.	na	N	na	na	na	na
Impact PSH-5: Physical control activities do not include the use of pesticides or herbicides; therefore, these activities would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.	na	N	na	na	na	na
Impact PSH-6: Physical control activities would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.	na	N	na	na	na	na
Impact PSH-7: Vegetation management activities would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.	na	na	N	na	na	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact PSH-8: Vegetation management activities would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.	na	na	N	na	na	na
Impact PSH-9: Vegetation management activities would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.	na	na	N	na	na	na
Impact PSH-10: Biological control activities would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.	na	na	na	N	na	na
Impact PSH-11: Biological control activities would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.	na	na	na	N	na	na
Impact PSH-12: Biological control activities would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.	na	na	na	N	na	na
Impact PSH-13: Chemical control activities would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.	na	na	na	na	N	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact PSH-14: Chemical control ground larviciding and adulticiding activities for mosquitoes would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.	na	na	na	na	N	na
Impact PSH-15: Chemical control ground larviciding and adulticiding activities would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.	na	na	na	na	N	na
Impact PSH-16: Chemical control (aerial application) activities would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.	na	na	na	na	N	na
Impact PSH-17: Chemical control (aerial application) activities would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.	na	na	na	na	N	na
Impact PSH-18: Chemical control (aerial application) activities would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.	na	na	na	na	N	na
Impact PSH-19: Chemical control for yellow jackets and ticks would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.	na	na	na	na	N	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact PSH-20: Chemical control of yellow jackets and ticks would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.	na	na	na	na	N	na
Impact PSH-21: Chemical control of yellow jackets and ticks would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.	na	na	na	na	N	na
Impact PSH-22: Other Nonchemical Control/Trapping Alternative activities would not increase demand for police, fire, or health-care services. Therefore, **no impact** would occur.	na	na	na	na	na	N
Impact PSH-23: The Other Nonchemical Control/Trapping Alternative would not create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials or through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment. Therefore, **no impact** would occur.	na	na	na	na	na	N

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact PSH-24: The Other Nonchemical Control/Trapping Alternative would not expose people or structures to a significant risk of loss, injury, or death involving wildland fires. Therefore, **no impact** would occur.	na	na	na	na	na	N
9. Water Resources						
Impact WR-1: The Surveillance Alternative would not result in increased soil erosion, so the impact to surface water would be **less than significant**. No mitigation is required.	LS	na	na	na	na	na
Impact WR-2: The Surveillance Alternative collection devices would not contact nor interact with the environment. **No impact** would occur to surface or groundwater.	N	na	na	na	na	na
Impact WR-3: The Physical Control Alternative's activities to modify water circulation, remove sediment, and maintain water control facilities to reduce habitat conditions for mosquito production would have a **less-than-significant** impact on soil erosion and water resources and no mitigation is required.	na	LS	na	na	na	na
Impact WR-4: Mechanical removal of vegetation from aquatic habitats would have a **less-than-significant** impact to surface water and **no impact** to groundwater resources. No mitigation is required.	na	na	LS, N	na	na	na
Impact WR-5: Application of the herbicides imazapyr and glyphosate would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	LS	na	na	na
Impact WR-6: Application of the herbicide triclopyr would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	LS	na	na	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact WR-7: For nonylphenol and APEs, application of these herbicides would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	LS	na	na	na
Impact WR-8: Application of modified plant oils and lecithins would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	LS	na	na	na
Impact WR-9: The Biological Control Alternative's use of mosquitofish limits wastewater discharges to the sanitary sewer or upland areas. Therefore, the use of mosquitofish would have a **less-than-significant** impact on surface and groundwater resources and no mitigation is required.	na	na	na	LS	na	na
Impact WR-10: The Biological Control Alternative's use of mosquitofish is limited to man-made water features that are hydrologically isolated from receiving waters. Therefore, the use of mosquitofish would have a **less-than-significant** impact on surface and groundwater resources and no mitigation is required.	na	na	na	LS	na	na
Impact WR-11: Application of the biological agents Bs, Bti, and spinosad would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-12: Application of methoprene would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-13: Application of the surfactant larvicides oxyethylene, mineral oils, and aliphatic petroleum hydrocarbons would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact WR-14: Application of the synergist PBO would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-15: Application of pyrethrins would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-16: Application of allethrins would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-17: Application of permethrin would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-18: Application of phenothrin would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-19: Application of prallethrin would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-20: Application of resmethrin would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-21: Application of tetramethrin would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-22: Application of deltamethrin would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-23 Application of esfenvalerate would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact WR-24: Application of etofenprox would have a **less-than-significant** impact to surface and groundwater resources and no mitigation is required.	na	na	na	na	LS	na
Impact WR-25: The Nonchemical Control/Trapping Alternative collection techniques use tamper-resistant or baited traps, which limit the exposure of chemical-containing baits to the environment **no impact** would occur to surface water or groundwater.	na	na	na	na	na	N
10. Effects on Air Quality						
Impact AQ-1: Based on the general inclusion of Surveillance Alternative emissions in the SIP emission inventory and the compliance with applicable air regulations, the Surveillance Alternative would not conflict with applicable air quality plans. Impacts would be **less than significant** and no mitigation is required**.**	LS	na	na	na	na	na
Impact AQ-2: Based on estimated daily emissions for each criteria pollutant, the Surveillance Alternative would not violate an ambient air quality standard. Impacts would be **less than significant** and no mitigation is required.	LS	na	na	na	na	na
Impact AQ-3: Based on estimated daily emissions for each criteria pollutant, the Surveillance Alternative would not result in a cumulatively considerable increase of nonattainment pollutants. Impacts would be **less than significant** and no mitigation is required.	LS	na	na	na	na	na
Impact AQ-4: Based on the estimated daily emissions for each criteria pollutant, the Surveillance Alternative would not expose sensitive receptors to substantial pollutant concentrations. Impacts would be **less than significant** and no mitigation is required.	LS	na	na	na	na	na
Impact AQ-5: The Surveillance Alternative would not subject people to objectionable odors. **No impact** would occur.	N	na	na	na	na	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact AQ-6: Based on the general inclusion of Physical Control Alternative emissions in the SIP emission inventory and the compliance with applicable air regulations, the Physical Control Alternative would not conflict with applicable air quality plans. Impacts would be **less than significant** and no mitigation is required.	na	LS	na	na	na	na
Impact AQ-7: Based on estimated daily emissions for each criteria pollutant, the Physical Control Alternative would not violate an ambient air quality standard. Impacts would be **less than significant** and no mitigation is required.	na	LS	na	na	na	na
Impact AQ-8: Based on estimated daily emissions for each criteria pollutant, the Physical Control Alternative would not result in a cumulatively considerable increase of nonattainment pollutants. Impacts would be **less than significant** and no mitigation is required.	na	LS	na	na	na	na
Impact AQ-9: Based on the estimated daily emissions for each criteria pollutant, the Physical Control Alternative would not expose sensitive receptors to substantial pollutant concentrations. Impacts would be **less than significant** and no mitigation is required.	na	LS	na	na	na	na
Impact AQ-10: The Physical Control Alternative would not subject people to objectionable odors. **No impact** would occur.	na	N	na	na	na	na
Impact AQ-11: Based on the general inclusion of Vegetation Management Alternative emissions in the SIP emission inventory and the compliance with applicable air regulations, the Vegetation Management would not conflict with applicable air quality plans. Impacts would be **less than significant** and no mitigation is required.	na	na	LS	na	na	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact AQ-12: Based on estimated daily emissions for each criteria pollutant, the Vegetation Management Alternative would not violate an ambient air quality standard. Impacts would be **less than significant** and no mitigation is required.	na	na	LS	na	na	na
Impact AQ-13: Based on estimated daily emissions for each criteria pollutant, the Vegetation Management Alternative would not result in a cumulatively considerable increase of nonattainment pollutants. Impacts would be **less than significant** and no mitigation is required.	na	na	LS	na	na	na
Impact AQ-14: Based on the estimated daily emissions for each criteria pollutant, the Vegetation Management Alternative would not expose sensitive receptors to substantial pollutant concentrations. Impacts would be **less than significant** and no mitigation is required.	na	na	LS	na	na	na
Impact AQ-15: The Vegetation Management Alternative would not subject people to objectionable odors. **No impact** would occur.	na	na	N	na	na	na
Impact AQ-16: Based on the general inclusion of Biological Control Alternative emissions in the SIP emission inventory and the compliance with applicable air regulations, the Biological Control Alternative would not conflict with applicable air quality plans. Impacts would be **less than significant** and no mitigation is required.	na	na	na	LS	na	na
Impact AQ-17: Based on estimated daily emissions for each criteria pollutant, the Biological Control Alternative would not violate an ambient air quality standard. Impacts would be **less than significant** and no mitigation is required.	na	na	na	LS	na	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact AQ-18: Based on estimated daily emissions for each criteria pollutant, the Biological Control Alternative would not result in a cumulatively considerable increase of nonattainment pollutants**.** Impacts would be **less than significant** and no mitigation is required.	na	na	na	LS	na	na
Impact AQ-19: Based on the estimated daily emissions for each criteria pollutant, the Biological Control Alternative would not expose sensitive receptors to substantial pollutant concentrations. Impacts would be **less than significant** and no mitigation is required.	na	na	na	LS	na	na
Impact AQ-20: The Biological Control Alternative would not subject people to objectionable odors. **No impact** would occur.	na	na	na	N	na	na
Impact AQ-21: Based on the general inclusion of Chemical Control Alternative emissions in the SIP emission inventory and the compliance with applicable air regulations, the Chemical Control Alternative would not conflict with applicable air quality plans. Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	LS	na
Impact AQ-22: Based on estimated daily emissions for each criteria pollutant, the Chemical Control Alternative would not violate an ambient air quality standard. Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	LS	na
Impact AQ-23: Based on estimated daily emissions for each criteria pollutant, the Chemical Control Alternative would not result in a cumulatively considerable increase of nonattainment pollutants**.** Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	LS	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact AQ-24: Based on the estimated daily emissions for each criteria pollutant, the Chemical Control Alternative would not expose sensitive receptors to substantial pollutant concentrations**.** Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	LS	na
Impact AQ-25: The Chemical Control Alternative could subject people to objectionable odors. Impacts could be **potentially significant but mitigable**, even with BMPs implemented.	na	na	na	na	SM	na
Impact AQ-26: Based on the general inclusion of Other Nonchemical Control/Trapping Alternative emissions in the SIP emission inventory and the compliance with applicable air regulations, the Other Nonchemical Control/Trapping Alternative would not conflict with applicable air quality plans**.** Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	na	LS
Impact AQ-27: Based on estimated daily emissions for each criteria pollutant, the Other Nonchemical Control/Trapping Alternative would not violate an ambient air quality standard. Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	na	LS
Impact AQ-28: Based on estimated daily emissions for each criteria pollutant, the Other Nonchemical Control/Trapping Alternative would not result in a cumulatively considerable increase of nonattainment pollutants. Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	na	LS
Impact AQ-29: Based on the estimated daily emissions for each criteria pollutant, the Other Nonchemical Control/Trapping Alternative would not expose sensitive receptors to substantial pollutant concentrations. Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	na	LS

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact AQ-30: The Other Nonchemical Control/Trapping Alternative would not subject people to objectionable odors. **No impact** would occur.	na	na	na	na	na	N
11. Effects on GHGs						
Impact GHG-1: Based on estimated annual CO_2e emissions, the Surveillance Alternative would not result in a cumulatively considerable amount of GHGs, and neither would the incremental contribution of the District. Impacts would be **less than significant** and no mitigation is required.	LS	na	na	na	na	na
Impact GHG-2: Based on the general inclusion of Surveillance Alternative emissions in the local and statewide GHG emission inventories, the Surveillance Alternative would not conflict with applicable plans, policies, or regulations for reducing GHG emissions. Impacts would be **less than significant** and no mitigation is required.	LS	na	na	na	na	na
Impact GHG-3: Based on estimated annual CO_2e emissions, the Physical Control Alternative would not result in a cumulatively considerable amount of GHGs, and neither would the incremental contribution of the District. Impacts would be **less than significant** and no mitigation is required.	na	LS	na	na	na	na
Impact GHG-4: Based on the general inclusion of Physical Control Alternative emissions in the local and statewide GHG emission inventories, the Physical Control Alternative would not conflict with applicable plans, policies, or regulations for reducing GHG emissions. Impacts would be **less than significant** and no mitigation is required.	na	LS	na	na	na	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact GHG-5: Based on estimated annual CO_2e emissions, the Vegetation Management Alternative would not result in a cumulatively considerable amount of GHGs, and neither would the incremental contribution of the District. Impacts would be **less than significant** and no mitigation is required.	na	na	LS	na	na	na
Impact GHG-6: Based on the general inclusion of Vegetation Management Alternative emissions in the local and statewide GHG emission inventories, the Vegetation Management Alternative would not conflict with applicable plans, policies, or regulations for reducing GHG emissions. Impacts would be **less than significant** and no mitigation is required.	na	na	LS	na	na	na
Impact GHG-7: Based on estimated annual CO_2e emissions, the Biological Control Alternative would not result in a cumulatively considerable amount of GHGs, and neither would the incremental contribution of the District. Impacts would be **less than significant** and no mitigation is required.	na	na	na	LS	na	na
Impact GHG-8: Based on the general inclusion of Biological Control Alternative emissions in the local and statewide GHG emission inventories, the Biological Control Alternative would not conflict with applicable plans, policies, or regulations for reducing GHG emissions. Impacts would be **less than significant** and no mitigation is required.	na	na	na	LS	na	na
Impact GHG-9: Based on estimated annual CO_2e emissions, the Chemical Control Alternative would not result in a cumulatively considerable amount of GHGs, and neither would the incremental contribution of the District. Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	LS	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact GHG-10: Based on the general inclusion of Chemical Control Alternative emissions in the local and statewide GHG emission inventories, the Chemical Control Alternative would not conflict with applicable plans, policies, or regulations for reducing GHG emissions. Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	LS	na
Impact GHG-11: Based on estimated annual CO_2e emissions, the Other Nonchemical Control/Trapping Control Alternative would not result in a cumulatively considerable amount of GHGs, and neither would the incremental contribution of the District. Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	na	LS
Impact GHG-12: Based on the general inclusion of Other Nonchemical Control/Trapping Control Alternative emissions in the local and statewide GHG emission inventories, the Other Nonchemical Control/Trapping Control Alternative would not conflict with applicable plans, policies, or regulations for reducing GHG emissions. Impacts would be **less than significant** and no mitigation is required.	na	na	na	na	na	LS

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
12. Effects on Noise						
Impact N-1: Use of equipment and vehicles under the Surveillance Alternative would increase noise levels during operations, but this increase would not exceed noise standards. This impact is **less than significant** based on the frequency and duration of the activity, resulting noise levels, and compliance with BMPs. No mitigation is required.	LS	na	na	na	na	na
Impact N-2: Use of equipment and vehicles under the Surveillance Alternative would cause a temporary increase in noise levels during operations. This increase would not be substantial and, therefore, is **less than significant** based on the frequency and duration of the activity, resulting noise levels, comparability to noise resulting from existing activities, and implementation of BMPs. No mitigation is required.	LS	na	na	na	na	na
Impact N-3: Use of equipment and vehicles under the Physical Control Alternative would increase noise levels during operations, but this increase would not exceed regulatory thresholds. This impact is **less than significant** based on the frequency and duration of the activity and resulting noise levels. No mitigation is required.	na	LS	na	na	na	na
Impact N-4: Use of equipment and vehicles under the Physical Control Alternative would cause a temporary increase in noise levels during operations. This increase would not be substantial, and therefore is **less than significant** based on the frequency and duration of the activity, resulting noise levels, comparability to noise resulting from existing activities, and implementation of BMPs. No mitigation is required.	na	LS	na	na	na	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact N-5: Use of equipment and vehicles under the Vegetation Management Alternative would increase noise levels during operations, but this increase would not exceed regulatory thresholds. This impact is **less than significant** based on the frequency and duration of the activity and resulting noise levels. No mitigation is required.	na	na	LS	na	na	na
Impact N-6: Use of equipment and vehicles under the Vegetation Management Alternative would cause a temporary increase in noise levels during operations. This increase would not be substantial, and therefore is **less than significant** based on the frequency and duration of the activity, resulting noise levels, comparability to noise resulting from existing activities, and implementation of BMPs. No mitigation is required.	na	na	LS	na	na	na
Impact N-7: Use of vehicles under the Biological Control Alternative would increase noise levels during operations, but this increase would not exceed regulatory thresholds. This impact is **less than significant** based on the frequency and duration of the activity and resulting noise levels. No mitigation is required.	na	na	na	LS	na	na
Impact N-8: Use of vehicles under the Biological Control Alternative would cause a temporary increase in noise levels during operations. This increase would not be substantial and, therefore, is **less than significant** based on the frequency and duration of the activity and resulting noise levels, and implementation of BMPs. No mitigation is required.	na	na	na	LS	na	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact N-9: Use of equipment and vehicles under the Chemical Control Alternative would increase noise levels during operations, but this increase would not exceed regulatory thresholds. This impact is **less than significant** based on the frequency and duration of the activity and resulting noise levels. No mitigation is required.	na	na	na	na	LS	na
Impact N-10: Helicopter/aircraft/airboat use under the Chemical Control Alternative would temporarily increase noise levels during operations, but would not exceed regulatory thresholds. This impact is **less than significant** based on the frequency and duration of the activity and resulting noise levels. No mitigation is required.	na	na	na	na	LS	na
Impact N-11: Use of equipment and vehicles under the Chemical Control Alternative would cause a temporary increase in noise levels during operations. This increase would not be substantial and, therefore, is **less than significant** based on the frequency and duration of the activity, resulting noise levels, comparability to noise resulting from existing activities, and implementation of BMPs. No mitigation is required.	na	na	na	na	LS	na
Impact N-12: Helicopter/aircraft/airboat use under the Chemical Control Alternative would temporarily increase noise levels during operations, but this increase would not be substantial. This impact is **less than significant** based on the frequency and duration of the activity, resulting noise levels, and implementation of BMPs. No mitigation is required.	na	na	na	na	LS	na

Table 15-1 Summary of Program Alternative Impacts

Impact Statement	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Nonchemical/ Trapping
Impact N-13: Use of equipment and vehicles under the Other Nonchemical Control/Trapping Alternative would increase noise levels during operations, but this increase would not exceed regulatory thresholds. This impact is **less than significant** based on the frequency and duration of the activity and resulting noise levels. No mitigation is required.	na	na	na	na	na	LS
Impact N-14: Use of equipment and vehicles under the Other Nonchemical Control/Trapping Alternative would cause a temporary increase in noise levels during operations. This increase would not be substantial and, therefore, is **less than significant** based on the frequency and duration of the activity, resulting noise levels, comparability to noise resulting from existing activities, and implementation of BMPs. No mitigation is required.	na	na	na	na	na	LS

LS = Less-than-significant impact
N = No impact
na = Not applicable
SM = Potentially significant but mitigable impact
SU = Significant and unavoidable impact

Table 15-2 Comparison of Reduced Program Alternatives to Proposed Program

	Proposed Program	Reduced Chemical Control Program	No Chemical Control Program
Alternative Component			
Surveillance	Included	Included	Included
Physical Control	Included	Included	Included
Vegetation Management > Physical Methods > Herbicides/Adjuvants	All physical methods and chemical options included	All physical methods and chemical options included	Includes physical methods only. > Excludes all herbicides and adjuvants. > Less effective with greater reliance on physical and mosquitofish options
Biological Control	Mosquitofish	Mosquitofish	Mosquitofish
Chemical Control	Use any or all pesticides and adjuvants, surfactants, and synergists listed in Chapter 2	Use less of or eliminate one or more of the following: > Deltamethrin > Etofenprox > Permethrin > Resmethrin > Pyrethrin > Bti liquid	Use none of the pesticides and adjuvants, surfactants, and synergists listed in Chapter 2
Nonchemical Control/Trapping	Included	Included	Included

Table 15-2 Comparison of Reduced Program Alternatives to Proposed Program

	Proposed Program	Reduced Chemical Control Program	No Chemical Control Program
Impacts			
Biological Resource Impacts (excluding ecological health)	No Impact or Less-than-Significant Impact	No Impact or Less-than-Significant Impact	No Impact or Less-than-Significant Impact
Physical Resource Impacts (excluding air quality odors)	No Impact or Less-than-Significant Impact	No Impact or Less-than-Significant Impact	No Impact or Less-than-Significant Impact
Air Quality - Odors	Potentially Significant but Mitigable Impact Less-than-Significant after Mitigation	Less-Than-Significant Impact	No Impact
Ecological Health Impacts	Less-than-Significant Impact	Less-than-Significant Impact	Potentially Significant Impact
Human Health Impacts	No Impact or Less-than-Significant Impact	No Impact or Less-than-Significant Impact	Significant and Unavoidable Impacts

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16 List of Preparers

The following personnel were directly involved in preparation and/or review of the PEIR:

16.1 Marin/Sonoma Mosquito and Vector Control District

District Board members and staff were involved in preparing and/or reviewing material.

Philip D. Smith.....District Manager/CEQA Project Manager

Erik Hawk .....Assistant District Manager

16.2 Consultant Team

Technical and support personnel from the consultant team that were involved in technical analyses, CEQA compliance, the environmental impact analyses and conclusions, and document preparation are listed in Table 16-1.

Table 16-1 Technical and Support Personnel

Preparers	Degree(s) Years of Experience	Role in Preparation	Experience and Expertise
Cardno ENTRIX (a Cardno, Inc. firm effective January 1, 2015)			
Hootkins, Susan	MUP, Urban and Regional Planning BA, Human Biology 41 years	Project Manager	> Environmental Planning > CEQA/NEPA Compliance > Socioeconomics > Land Use
Technical Personnel			
Bonin, Adam	PhD, Environmental Science & Resources BS, Environmental Management 20 years	Ecological Hazard Assessment; Human Health Hazard Assessment	> Environmental Microbiology > Ecological Risk Assessment > Environmental Chemistry > Quality Assurance/Quality Control Chemistry
Brice, Doug	BS, Geography: Emphasis on GIS and Environmental Planning 20 years	GIS Coordinator Figures	> GIS Systems > Field/Data Collection > Geospatial Application Development > Environmental Planning
Clare, Anna	MA, Geography BS, Geographic Information System 8 years	GIS Analyst Figures	> GIS System > Environmental Analysis > Physical Geography > Cartographic Research

Preparers	Degree(s) Years of Experience	Role in Preparation	Experience and Expertise
Floyd, Emily	PhD, Ecology BA, Marine Science 11 years	Aquatic Ecology	> Aquatic Ecology > Fish Physiology > Ecotoxicology > Habitat Alteration
Gibeson, Brian	BA, Biology AS, Biology 37 years	Terrestrial Ecology	> Terrestrial Biology > Herpetology > Marine Biology/ Marine Mammalogy > Project Management > Conservation Biology > Endangered and Threatened Species > Herpetology > Ichthyology > Marine Ecology > Ornithology > Wildlife Ecology > Zoology > Invasive Species Management
Knaapen, Anthony	BA, General Biology 2 years	Staff Scientist	> Public Scoping > Technical Support
Koppel, Emily	MS, Biology BS, Fisheries & Wildlife 8 years	Toxicity Assessment Aquatic Ecology	> Parasite and Disease Ecology > Marine Biology > Terrestrial Ecology > Environmental Toxicology
Lebednik, Gretchen	MS, Botany BA, Environmental Biology 25 years	Terrestrial Ecology	> Vegetation Ecology > Habitat Restoration > Rare plant Surveys > Wetland Delineation > Riparian Vegetation assessment
Lee, Michele	MS, Wildland Resource Science BA, Psychology 15 years	Terrestrial Ecology	> Vegetation Ecology > Habitat Restoration > Rare plant Surveys > Wetland Delineation > Riparian Vegetation assessment > Public Services and Hazards

Preparers	Degree(s) Years of Experience	Role in Preparation	Experience and Expertise
Pavich, Steve	MS, Agricultural and Resource Economics BA, Economics 11 Years	Urban and Rural Land Use	> Socioeconomics > Resource Economics > Recreation > Land use planning
Thompson, Tim	MS, Geological Sciences BS, Geological Sciences 27 years	Water Resources	> Water Resource Science > Regulatory Issues
Williams, Bill	PhD, Physiology and Biophysics MS, Physiology and Biophysics BA, Physiology and Biophysics 35 years	Ecological Hazard Assessment Task Leader; Human Health Hazard Assessment Task Leader; Terrestrial Biology	> Ecological and Human Health Risk Assessments > Natural Resource Damage Assessments > Pesticide Regulation > Toxicology
Wise, Larry	MA, Marine Biology BS, Marine Biology and Limnology 25 years	Aquatic Biology Aquatic Ecology	> Ecology of Freshwater, Estuarine, and Marine Systems > CEQA/NEPA Compliance
Woodman, Lorraine	PhD, Anthropology MA, Anthropology BA, Anthropology 31 years	Noise Analysis	> CEQA/NEPA Compliance > Habitat Conservation
Support Personnel			
Eschen, Iris	37 years	Production Manager	> Production management and coordination, word processing, desktop publishing
Dillon, Reinhold	BA, History MA, Medieval History and Literature 32 years	Technical Editing Style Guide	> Technical Editing > Language Control
Butler, Karen	29 years	Production Specialist	> Production Support
Grant Visual Technology			
Grant, Douglas	BS, Geological Sciences 22 years	Noise	> Geology > Engineering Design > Acoustical Modeling
Somach Simmons and Dunn			
Taber, Kelley	JD Major AB, East Asian Studies State Bar of CA, 1996 20 years	CEQA Compliance	> Legal Support > CEQA and water quality focus > CDFA consultant team

Preparers	Degree(s) Years of Experience	Role in Preparation	Experience and Expertise
URS Corporation (an AECOM firm effective October 2014)			
Cooke, Terry	MS, Marine Sciences BA, Chemistry 34 years	Water Resources	> TMDLs / Water Quality > Stormwater Management > NPDES Permitting
de Berry, Bonnie	MFS, Aquatic Chemistry BS, Natural Resources and Environmental Sciences 15 years	Water Resources	> Water Quality > Hydrology > Stormwater Management > Wetland Mitigation > NPDES Permitting
Nielsen, Elizabeth	MS, Environmental Engineering BS, Biology 14 years	Water Resources	> Water Quality > Ecological Risk Assessment > NPDES Permitting
Yorke Engineering, LLC			
Boyes, Brad	MBA, Project Management BS, Environmental Engineering 35 years	Air Quality Climate Change	> Air Quality > Climate Change / GHGs > Health Risk Assessments > Risk Management Plans > Environmental Site Assessment

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Integrated Vector
Management Program

APPENDIX
A

BIOLOGICAL RESOURCES
TECHNICAL REPORT

Biological Resources Technical Report

Integrated Mosquito and Vector Management Programs for Nine Districts

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Cardno ENTRIX

Shaping the Future

Biological Resources Technical Report

Project Name: Integrated Mosquito and Vector Management Programs for Nine Districts

Date: June 2013

Prepared for:

Alameda County Mosquito Abatement District
Alameda County Vector Control Services District
Contra Costa Mosquito and Vector Control District
Marin/Sonoma Mosquito and Vector Control District
Napa County Mosquito Abatement District
Northern Salinas Valley Mosquito Abatement District
San Mateo County Mosquito and Vector Control District
Santa Clara County Vector Control District
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Acronyms

ACMAD	Alameda County Mosquito Abatement District
ACVCSD	Alameda County Vector Control Services District
CCMVCD	Contra Costa Mosquito and Vector Control District
CDFA	California Department of Food and Agriculture
CDFW	California Department of Fish and Wildlife
CDPH	California Department of Public Health
CDPR	California Department of Pesticide Regulation
MSMVCD	Marin/Sonoma Mosquito Vector Control District
NCMAD	Napa County Mosquito Abatement District
NMFS	National Marine Fisheries Service
NSVMAD	Northern Salinas Valley Mosquito and Vector Control District
RWQCB	Regional Water Quality Control Board
SCCVCD	Santa Clara County Vector Control District
SCMAD	Solano County Mosquito Abatement District
SMCMVCD	San Mateo County Mosquito and Vector Control District
SWRCB	State Water Resources Control Board
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service

1 Introduction

This report provides a description of the environmental setting for biological resources for the Integrated Mosquito and Vector Management Programs (Programs) for nine mosquito abatement and/or vector control districts in northern California. The Programs provide for mosquito and/or vector control activities within each District's Program Area. The nine District Program Areas include both the areas within the districts and the surrounding counties where the districts may provide mosquito and/or other vector management services when requested. The nine districts are: Alameda County Mosquito Abatement District (ACMAD), Alameda County Vector Control Services District (ACVCSD), Contra Costa Mosquito and Vector Control District (CCMVCD), Marin/Sonoma Mosquito Vector Control District (MSMVCD), Napa County Mosquito Abatement District (NCMAD), Northern Salinas Valley Mosquito Abatement District (NSVMAD), San Mateo County Mosquito and Vector Control District (SMCMVCD), Santa Clara County Vector Control District (SCCVCD), and the Solano County Mosquito Abatement District (SCMAD).

The immediate nine District Service Areas are located in the following nine counties of the state: Alameda, Contra Costa, Marin, Monterey (NSVMD), Napa, Sonoma, Solano, San Mateo, and Santa Clara. The nine District Program Areas addressed in this report also include the ten surrounding counties: Mendocino, Merced, Lake, Sacramento, San Benito, San Francisco, San Joaquin, Santa Cruz, Stanislaus, Yolo, and the portion of Monterey County south of the NSVMAD. Control activities may also be provided in areas adjacent to the District Service Areas upon request of the adjacent jurisdictions to protect the health and safety of residents in adjacent jurisdictions. Actions that would be taken outside of the nine Districts' Service Areas are the same types of actions undertaken within the Districts' Service Areas and in similar types of habitats or sites.

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2 Environmental Setting

2.1 Aquatic Habitat

Due to the extent of the nine Program Areas, hydrologic provinces and fish species assemblages presented in Moyle (2002) have been used to describe the areas where treatments would be implemented (Figure 2-1).The hydrologic provinces (as described in Moyle 2002) potentially affected by the Programs are described below. The provinces for each district and its boundary counties are provided in Table 2-1.

Table 2-1 Hydrologic Provinces by District and Adjacent Counties

District	Sacramento – San Joaquin Province			North Coast Province	South Coast Province
	Central Valley Subprovince	Clear Lake Subprovince	Monterey Bay Subprovince		
ACMAD	yes	--	--	--	--
ACMAD adjacent	yes	--	yes	--	--
ACVCSD	yes	--	--	--	--
ACVCSD adjacent	yes	--	yes	--	--
CCMVCD	yes	--	--	--	--
CCMVCD adjacent	yes	--	--	--	--
MSMVCD	yes	--	--	yes	--
MSMVCD adjacent	yes	yes	--	yes	--
NCMAD	yes	--	--	yes	--
NCMAD adjacent	yes	yes	--	yes	--
NSVMAD	--	--	yes	--	--
NSVMAD adjacent	yes	--	yes	--	--
SMCMVCD	yes	--	yes	--	--
SMCMVCD adjacent	yes	--	yes	--	--
SCCVCD	yes	--	yes	--	--
SCCVCD adjacent	yes	--	yes	--	--
SCMAD	yes	--	--	--	yes
SCMAD adjacent	yes	--	--	yes	yes

2.1.1 Sacramento-San Joaquin Province

2.1.1.1 Central Valley Subprovince

The Central Valley Subprovince is drained by the Sacramento and San Joaquin rivers. Species native to this region are distinct with respect to morphology, physiology, and life-history patterns, reflecting an evolutionary history of adaptation to a unique climate characterized by extended droughts as well as massive floods (Moyle 2002). The hot Mediterranean climate of the Central Valley is characterized by hot, dry summers and cool, damp winters. The rainy season occurs from mid-Autumn through spring, with the

northern half of the Central Valley receiving greater precipitation than the semidesert southern half. The four main fish assemblages that occur in the Central Valley Subprovince are (1) the rainbow trout assemblage, (2) the California roach assemblage, (3) the pikeminnow-hardhead-sucker assemblage, and (4) the deep-bodied assemblage.

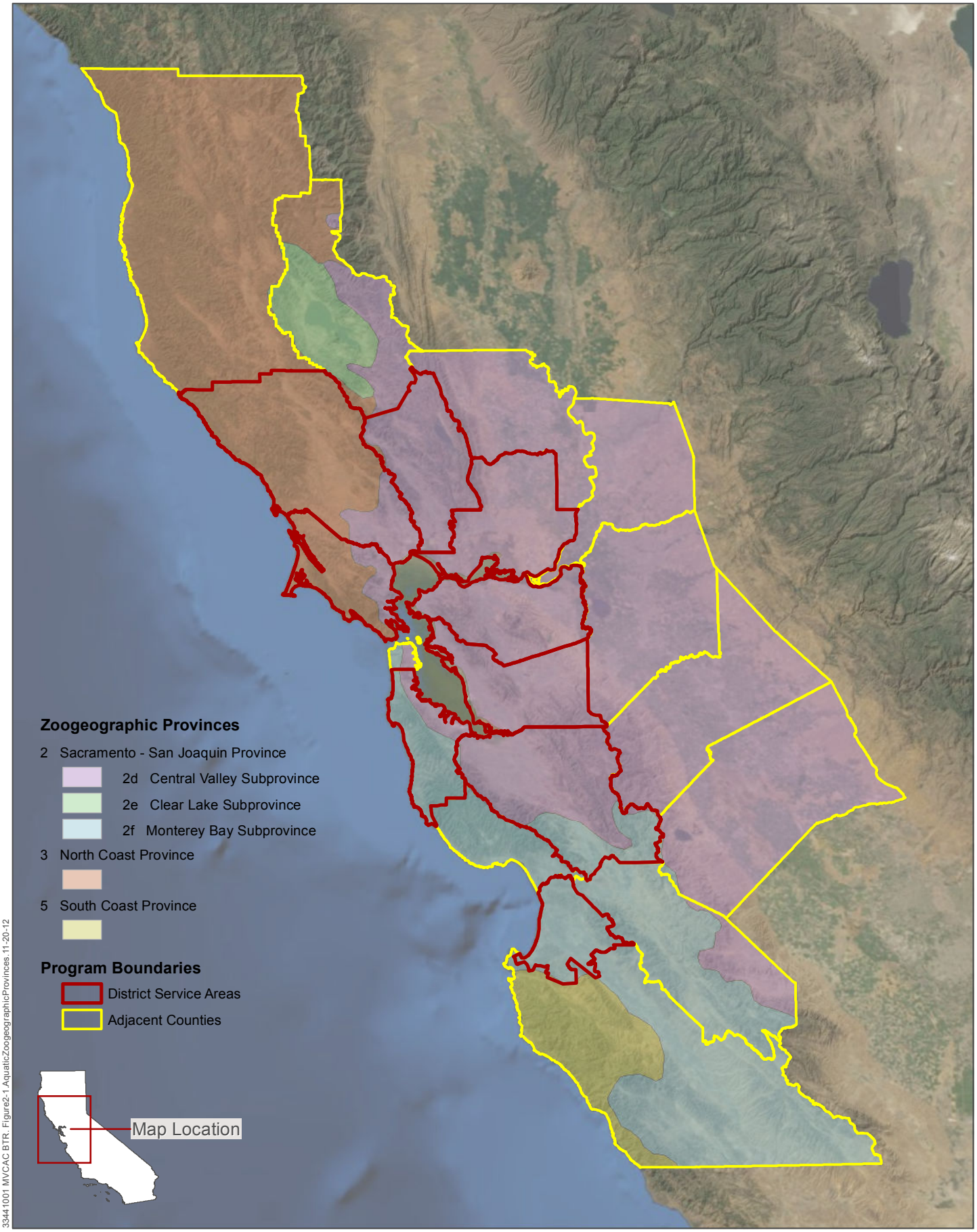
2.1.1.1.1 San Francisco Estuary

The Sacramento-San Joaquin River Delta lies near the confluence of the Sacramento and San Joaquin rivers between the towns of Hood, Vernalis, and Martinez. The Delta is the transition zone between freshwater river habitats of the Central Valley rivers and the successively more saline habitats of Suisun, San Pablo, and San Francisco bays. These habitats are affected by the tides, which cause diurnal changes in flow patterns and water quality, as well as river outflow, which cause more seasonal changes in habitat. The Delta has been substantially modified from its historic condition by levees, agriculture, toxic contaminants from municipal, industrial, and agricultural sources, and water diversions. The estuary is home to a diverse array of native and introduced species, some of which reside in the estuary throughout the year, and others that use the estuary seasonally. These species include winter-run and spring-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley steelhead (*Oncorhynchus mykiss*), green sturgeon (*Acipenser medirostris*), delta smelt (*Hypomesus transpacificus*), and longfin smelt (*Spirinchus thaleichthys*), all of which are listed by either the federal or California Endangered Species Acts.

The fish fauna that currently characterizes this system (including native and nonnative species) can be most easily described with respect to feeding guilds: planktivores, small benthic predators, bottom-feeding omnivores, and piscivores. The main planktivores in the estuary include the native delta and longfin smelt, hitch (*Lavinia exilicauda*), and several introduced species. Small benthic predators include native prickly sculpin (*Cottus asper*), tule perch (*Hysterocarpus traski*), starry flounder (*Platichthys stellatus*), juvenile white sturgeon (*Acipenser transmontanus*), juvenile Sacramento splittail (*Pogonichthys macrolepidotus),* and Pacific staghorn sculpin (*Leptocottus armatus*), as well as introduced species. Bottom-feeding omnivores include native adult Sacramento splittail, and Sacramento sucker (*Catostomus occidentalis*) and the introduced common carp (*Cyprinus carpio*). The most abundant piscivores in the system are introduced species: striped bass (*Morone saxatilis*), white catfish (*Ameiurus catus*), channel catfish (*Ictalurus punctatus*), and largemouth bass (*Micropterus salmoides*), which often prey on smaller migratory fishes such as juvenile salmon and steelhead (Moyle 2002).

2.1.1.1.2 Central Valley Floor

The Central Valley floor is composed of warm waterways including sluggish river channels, swamps, sloughs, and long stretches of open water. The Central Valley floor fish fauna is composed primarily of species from the deep-bodied fish assemblage. Native deep-bodied fishes, such as Sacramento perch (*Archoplites interruptus*) and tule perch, and juvenile fishes occupy the stagnant backwaters, while specialized adult cyprinids (hitch, Sacramento blackfish [*Orthodon microlepidotus*], and splittail) inhabit the long stretches of open water. Large Sacramento pikeminnows (*Ptychocheilus grandis*) and suckers are also abundant, migrating upstream to spawn in tributaries. Anadromous salmon, steelhead, and sturgeon pass through this zone on their way upstream to spawn (Moyle 2002). This domain is now dominated by introduced species.



3344 1001 MVCAC BTR. Figure2-1 AquaticZoogeographicProvinces.11-20-12

Source: Chris Mari van Dyck, 2000

INTEGRATED MOSQUITO & VECTOR MANAGEMENT PROGRAMS

Aquatic Zoogeographic Provinces

Figure 2-1

2.1.1.1.3 Central Valley Foothills

Central Valley foothill streams and rivers ascend from the valley floor to the Sierra and Coast Range mountains. These streams and rivers are home to three fish assemblages as defined by Moyle (2002). From lowest to highest elevation, they are the pikeminnow-hardhead-sucker assemblage, the California roach assemblage, and the rainbow trout assemblage. The pikeminnow-hardhead-sucker assemblage occurs just above the valley floor at elevations of 80 to 1,500 feet. This assemblage typically inhabits streams with average summer flows of >300 liters/second, with deep, rocky pools and wide shallow riffles. Water quality and habitat complexity is usually high, although some streams may become intermittent during summer, and summer water temperatures may exceed 25°C. Sacramento pikeminnow and Sacramento sucker are generally the most abundant fishes of this assemblage, while hardhead (*Mylopharodon conocephalus*) are confined to cooler waters in reaches with deep, rock-bottomed pools.

The California roach assemblage overlaps substantially in elevation with the pikeminnow-hardhead-sucker assemblage, although it does not extend to the lowest elevations. This assemblage is found in small, warm tributaries to larger streams that flow through open foothill woodlands of oak and foothill pine. These streams are typically intermittent during summer, resulting in the formation of stagnant pools that can exceed 30°C during the day. In the winter and spring these streams are swift and vulnerable to flooding. These streams provide habitat for the California roach (*Lavinia symmetricus*), which is capable of withstanding high temperature and low oxygen levels due to its small size.

The rainbow trout assemblage overlaps with the upper elevations of the pikeminnow-hardhead-sucker and California roach assemblage and extends to the highest elevations. These streams are characterized by swift, permanent flows, steep gradients, and cool temperatures. The water is well oxygenated and cover is abundant. Sculpin (*Cottus* spp.), Sacramento sucker, and speckled dace (*Rhinichthys osculus*) are often part of this assemblage. Introduced brook trout (*Salvelinus fontinalis*) and brown trout (*Salmo trutta*) are often found in this assemblage as well, although they generally do not occur at the lower elevations.

2.1.1.1.4 Central Valley Reservoirs

Dams constructed to store water in the Central Valley of California now provide habitat for a mix of exotic and native species. The nature of the fish fauna in a given reservoir is determined by its elevation, size, location, and water quality. California reservoirs range from clear, oligotrophic, cold-water impoundments at high elevations to turbid, eutrophic, warm-water impoundments at low elevations, but most are found at middle elevations in the foothills. These reservoirs usually provide habitat for warm-water fishes in surface and edge waters and salmonids in deeper, cooler water.

2.1.1.2 Clear Lake Subprovince

The Clear Lake Subprovince includes Clear Lake, located in a small drainage basin in the Coast Range at an approximately 1,319-foot elevation, and the surrounding watershed. The native fish fauna primarily consists of species found in quiet waters of the Central Valley floor (Moyle 2002). The lake historically supported populations of many native species from the deep-bodied fish assemblage of the Central Valley. These fish were variants adapted to lake environments. Today only four natives, hitch, blackfish, tule perch, and prickly sculpin, have large populations, and many introduced species have come to dominate the lake's fauna. The streams in this subprovince provide a home for Sacramento pikeminnow, Sacramento sucker, California roach, and rainbow trout (*Oncorhynchus mykiss*).

2.1.1.3 Monterey Bay Subprovince

The Monterey Bay Subprovince is composed of three major streams that flow into Monterey Bay, the San Lorenzo, Pajaro, and Salinas rivers, as well as the small coastal drainages from Santa Cruz to San Francisco (Moyle 2002). This subprovince had nearly the full complement of species from the Central Valley floor, excluding hardhead and splittail), as well as saltwater dispersant fishes including the Pacific

lamprey (*Lampetra tridentata*), threespine stickleback (*Gasterosteus aculeatus*), prickly sculpin, steelhead, and Coho salmon (*Oncorhynchus kisutch*) (Moyle 2002).

2.1.2 North Coast Province

The North Coast Province consists of coastal drainages from the Golden Gate in San Francisco Bay to the Smith River on the Oregon border, excluding the mouth of the lower Klamath River (Moyle 2002). North Coast streams are highly variable, ranging from warm, intermittent streams to permanent, cold-flowing streams. Because these streams drain low mountain ranges and do not develop snowpacks, their flow patterns largely reflect rainfall. As a consequence, they may be raging torrents in winter and spring, and small trickling streams in summer. Coastal streams and rivers within this province have largely independent zoogeographic histories, but are very similar with respect to their faunal assemblages. The Russian River is unique in this region in that it provides a home to much of the Sacramento-San Joaquin freshwater dispersant fauna. In general, however, anadromous and other saltwater dispersant fishes dominate the fauna in the North Coast Province.

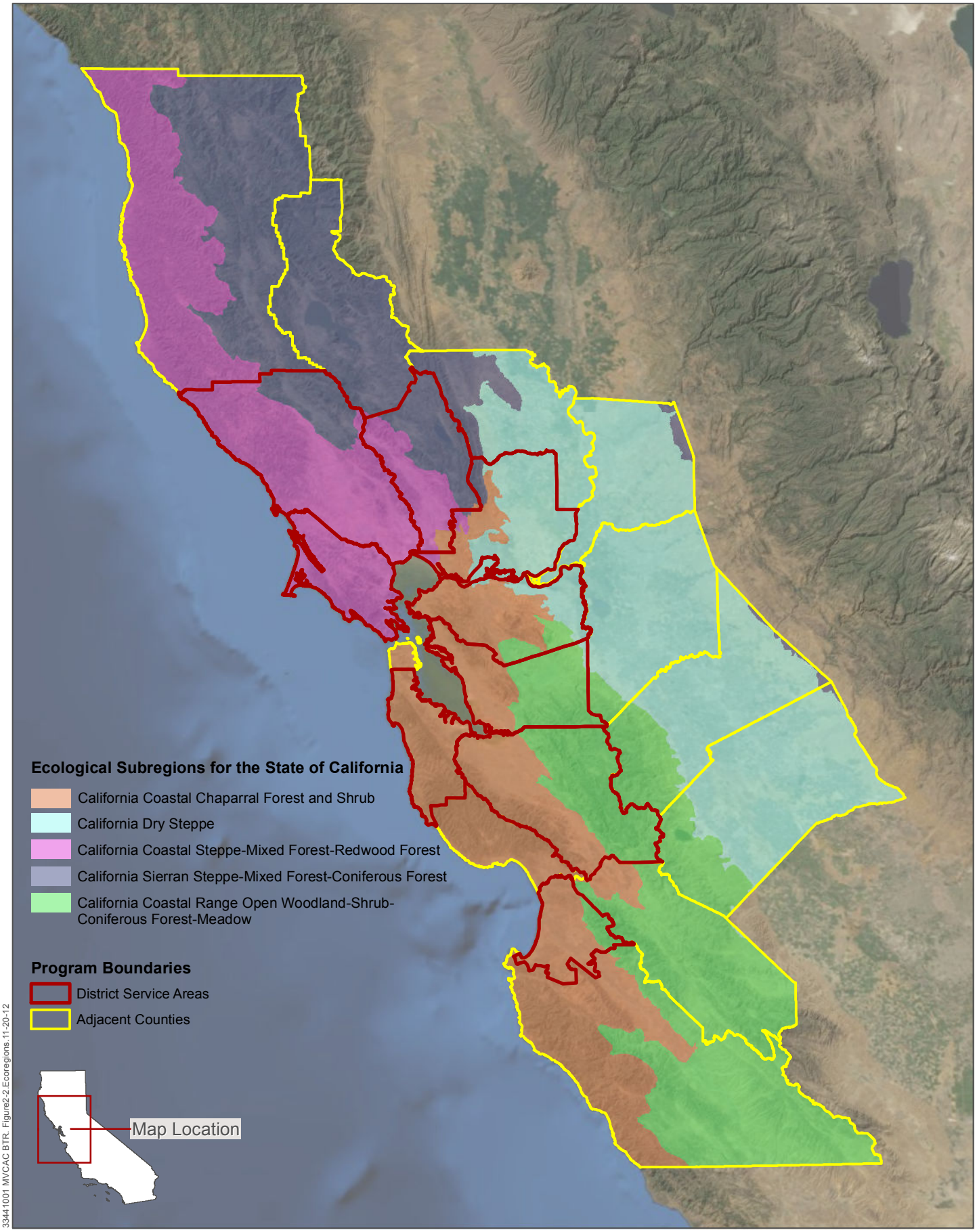
Three intergrading fish assemblages are observed in this area: resident trout, anadromous fishes, and estuarine fishes. Most of the fish in this subprovince are anadromous or saltwater dispersant species, but a few freshwater fish from the Central Valley are also observed here. The resident trout assemblage occupies the uppermost reaches of larger watersheds, typically above natural barriers to migration. The water is cold, swift, and well- oxygenated. This area is typically dominated by rainbow trout. The anadromous fish assemblage (steelhead, Coho, and lamprey) is distributed as far upstream as fishes can migrate and downstream to reaches influenced by tidal action. Streams in this area are cold and fast moving; however, pools become increasingly large and frequent as streams approach the ocean. Long stretches of shallow riffles over rock, gravel, or sand between pools there are used by anadromous salmon for spawning. Lamprey, three-spine stickleback, prickly and coast-range sculpin (*Cottus aleuticus*), California roach and Sacramento sucker are also present. The estuarine fish assemblage occupies areas of streams affected by daily tides. Consequently, these fish experience reversing currents, temperature fluctuation, and salinity gradients daily. Species found in the estuarine areas include threespine stickleback, prickly sculpin, coastrange sculpin, staghorn sculpin, topsmelt (*Atherinops affinis*), starry flounder, and tidewater goby (*Eucyclogobius newberryi*) (Moyle 2002).

2.1.3 South Coast Province

The South Coast Province includes 10 large watersheds and many smaller coastal drainages from Baja California north to Monterey Bay. This province has somewhat limited fish fauna with a relatively long, complex history due to the arid conditions and active geological history that characterize these regions (Moyle 2002). Except for streams within the Los Angeles Basin, most of this province has been dominated by salt water dispersants, including anadromous rainbow trout and Pacific lamprey. Multiple euryhaline marine species are found in lagoons and lower reaches of streams within the South Coast Province, but the tidewater goby and California killifish (*Fundulus parvipinnis*) are two species that are found only in these habitats (Moyle 2002).

2.2 Terrestrial Habitats

Due to the extent of the Program Areas, terrestrial habitats are described at the province level (McNab and Ayers 1996). The Program Areas include portions of five provinces (Figure 2-2), all of which occur in one or more of the District Program Areas. The provinces for each district and its boundary counties are provided in Table 2-2.



3344 1001 MVCAC BTR. Figure2-2.Ecoregions.11-20-12

Source: US Forest Service, Pacific Southwest Region, Ecological Subregions for the State of California

INTEGRATED MOSQUITO & VECTOR MANAGEMENT PROGRAMS

Ecoregions in Program Areas

Figure 2-2

Table 2-2 Ecoregion Provinces by District and Adjacent Counties

District	California Dry Steppe	California Coastal Chaparral, Forest, and Scrub	California Coastal Steppe, Mixed Forest, Redwood Forest	California Sierran Steppe, Mixed Forest, Coniferous Forest	California Coastal Range Open Woodland, Shrub, Coniferous Forest, Meadow
ACMAD	yes	yes	--	--	yes
ACMAD adjacent	yes	yes	--	--	yes
ACVCSD	yes	yes	--	--	yes
ACVCSD adjacent	yes	yes	--	--	yes
CCMVCD	yes	yes	--	--	yes
CCMVCD adjacent	yes	yes	--	--	yes
MSMVCD	--	--	yes	yes	--
MSMVCD adjacent	--	yes	yes	yes	--
NCMAD	--	yes	yes	yes	--
NCMAD adjacent	yes	yes	yes	yes	--
NSVMAD	--	yes	--	--	yes
NSVMAD adjacent	--	yes	--	--	yes
SMCMVCD	--	yes	--	--	--
SMCMVCD adjacent	--	yes	--	--	yes
SCCVCD	--	yes	--	--	yes
SCCVCD adjacent	yes	yes	--	--	yes
SCMAD	yes	yes	yes	yes	--
SCMAD adjacent	yes	yes	yes	yes	--

2.2.1 California Dry Steppe

The California Dry Steppe province once covered the Central Valley of California. Although much of the Central Valley is now subject to agricultural uses and grazing, it was originally dominated by native grasses and wildflowers, including bunchgrasses (McNab and Ayers 1996). While remnant stands of native grasslands remain, much of the uncultivated land in this valley is now dominated by exotic species such as wild oats (*Avena* spp.), brome grasses (*Bromus* spp.), filarees (*Erodium* spp.), Italian ryegrass (*Lolium perenne* ssp. *multiflorum*), and both exotic and native fescues (*Vulpia* spp.). Native wildflowers and some native grasses persist among the exotic species. Rivers in the Sacramento Valley and northern San Joaquin Valley are fringed with riparian vegetation, while freshwater marshes line the lower reaches of the San Joaquin and Sacramento rivers. Portions of this province are in the ACMAD, ACVCSD, CCMVCD and the SCMAD. Additionally, portions of this province are in adjacent counties for the ACMAD, ACVCSD, CCMVCD, NCMAD, SCCVCD, and SCMAD.

2.2.2 California Coastal Chaparral, Forest, and Scrub

The lands along the central and southern coasts of California, as well as the seaward side of the Coast Ranges in this area, are part of the California Coastal Chaparral, Forest, and Scrub province (McNab and Ayers 1996). A variety of plant communities are found in this province. Representative plant communities include coastal scrubs dominated by coyote bush (*Baccharis pilularis*), California sagebrush (*Artemisia californica*), and bush lupine (*Lupinus* spp.) or sages (*Salvia* spp.) and chaparral types dominated by chamise (*Adenostoma fasciculatum*) and various manzanitas (*Arctostaphylos* spp.) and ceanothus (*Ceanothus* spp.). Gentler slopes support live oak and white oak woodlands and forests and coastal plains and valleys support grassland communities. Riparian forests and willow scrub grow along streams (Holland 1986). However, much of the coastal plain and valley floors have been converted to agriculture or urban uses. Portions of this province are in all districts except the MSVCD. Additionally, portions of this province are in adjacent counties for all nine districts.

2.2.3 California Coastal Steppe, Mixed Forest, and Redwood Forest Province

The California Coastal Chaparral, Forest, and Scrub province covers the lands along the north coast of California and the seaward side of the North Coast Ranges (McNab and Ayers 1996). Inland slopes support a mixed evergreen forest dominated by coast live oak (*Quercus agrifolia*), tan oak (*Lithocarpus densiflorus*), madrone (*Arbutus menziesii*), and Douglas fir. Redwood forests (*Sequoia sempervirens*) are typically found on the seaward slopes of coastal northwestern California. Associated species include Douglas fir (*Pseudotsuga menziesii*) and other conifers (Holland 1986). Oaks may form distinct patches of oak woodland (Holland 1986). Portions of this province are in the MSMVCD, NCMAD, and SCMAD, as well as adjacent counties for these three districts.

2.2.4 Sierran Steppe–Mixed Forest–Coniferous Forest–Alpine Meadow Province

The Sierran Steppe–Mixed Forest–Coniferous Forest–Alpine Meadow province covers most of interior Northern California, as well as the Sierra Nevada, and extends into southern Oregon (MacNab and Ayers 1996). Shrub and conifer communities cover the lower slopes and foothills, from about 1,500 to 4,000 feet. On higher slopes, foothill pine and blue oak often dominate, forming open woodlands. Chaparral covers extensive areas. Montane forests are found between about 2,000 and 6,000 feet in the Cascades. The dominant trees are ponderosa pine (*Pinus ponderosa*), Jeffrey pine (*Pinus jeffreyi*), Douglas fir, firs (*Abies* spp.), and incense cedar (*Calocedrus decurrens*), but several other conifers also occur. Dense chaparral communities of manzanita, buckbrush, and buckthorn may carpet open slopes or provide understory in open forests (Holland 1986). Other communities are found in the Sierra Nevada and at higher elevations. They are not described in this section because they are outside the Program Area.

Portions of this province are in the MSMVCD, NCMAD, and SCMAD, as well as adjacent counties for these three districts.

2.2.5 California Coastal Range Open Woodland-Shrub-Coniferous Forest–Meadow Province

The California Coastal Range Open Woodland-Shrub-Coniferous Forest–Meadow province covers the lands along the interior of the Central and South Coast ranges of California, including part of the Transverse Ranges of Southern California (MacNab and Ayers 1996).This province also supports live oak forests, woodlands, and chaparral, but the conditions are drier than in the California Coastal Chaparral, Forest, and Scrub province. Interior live oaks (*Quercus wislizenii*) and other oaks are found here, in addition to coast live oak and madrone (Holland 1986). Interior valleys support grassland and coastal scrub communities. As in the neighboring provinces, a riparian forest grows along streams. At higher elevations and near the ocean, chaparral may be interspersed with coniferous forests.

Portions of this province are in the ACMAD, ACVCSD, CCMVCD, NSVMAD, SMCMVCD, SCCVCD, and SCMAD. Additionally, portions of this province are in adjacent counties for these seven districts and the SMCMVCD.

2.3 Sensitive Natural Communities

Sensitive Natural Communities include both occurrences of certain rarer community types, or specific stands of ecological importance for other community types. Approximately 50 types of natural communities that are tracked in the California Natural Diversity Database (CDFG 2012) occur in the Program Area. These types include dune, scrub, chaparral, native grassland, wildflower, alkali, vernal pool, bog, seep, fen, marsh, riparian scrub, riparian woodland, riparian forest, and nonriparian forests and woodlands.

2.4 Special Status Species

Many special-status species occur in the Program Area, including 157 species that are listed as endangered or threatened under the federal or California Endangered Species Acts (CDFG 2012). A full list of these species and brief summaries of their status and habitats is provided in Attachment A, Lists of Species.

2.5 Regulatory Setting

This section focuses on the regulations primarily addressing plant and animal species. Regulations governing pesticide use are contained in Sections 6.1.3 and 7.1.4 of the Draft PEIR.

2.5.1 Federal

2.5.1.1 Endangered Species Act of 1973 (16 USC Section 1531 et seq.; 50 CFR Parts 17 and 222)

This law includes provisions for protection and management of species that are federally listed as threatened or endangered and designated critical habitat for these species. This law prohibits “take” of federally listed species, except as authorized under an incidental take permit or incidental take statement. The United States Fish and Wildlife Service (USFWS) is the administering agency for this authority for freshwater species. The National Marine Fisheries Service (NMFS) is the administering agency for anadromous species.

2.5.1.2 Magnusson-Stevenson Fishery Conservation and Management Act 1996 (Public Law 94-265)

This law provides for the conservation and management of all fish resources within the exclusive economic zone of the U.S. and supports and encourages the implementation and enforcement of international fisheries agreements for conservation and management of highly migratory species. It called for the establishment of Regional Fisheries Management Councils to develop, implement, monitor, and revise fish management plans to promote domestic commercial and recreational fishing. Specifically to this Program, it calls for the protection of essential fish habitat in review of projects conducted under federal permits, licenses, or other authorities that affect or have the potential to affect such habitat. The NMFS is responsible for the administration of this act.

2.5.1.3 Migratory Bird Treaty Act (16 USC Section(s) 703-711; 50 CFR Subchapter B)

This law includes provisions for protection of migratory birds, including basic prohibitions against any taking not authorized by federal regulation. The administering agency is the USFWS.

2.5.1.4 Bald and Golden Eagles Protection Act (16 USC Section(s) 668; 50 CFR Part 22)

This act makes it illegal to import, export, take (which includes molest or disturb[1]), sell, purchase, or barter any bald eagle or golden eagle or part thereof. The golden eagle, however, is accorded somewhat lighter protection under this act than the bald eagle. The administrating agency is the USFWS.

2.5.1.5 Clean Water Act of 1977 [33 USC Section(s) 1251-1376; 30 CFR Section(s) 330.5 (a)(26)]

These sections provide for the protection of wetlands. The administering agency for the above authority is the United States Army Corps of Engineers (USACE).

2.5.1.6 Executive Order 11990, Protection of Wetlands (May 24, 1977)

This order provides for the protection of wetlands. The administering agency for the above authority is the USACE.

2.5.1.7 Stipulated Injunction and Order, Protection of California Red-Legged Frog from Pesticides

On October 20, 2006, the U.S. District Court for the Northern District of California imposed no-use buffer zones around California red-legged frog upland and aquatic habitats for certain pesticides. This injunction and order will remain in effect for each pesticide listed in the injunction until the USEPA goes through formal 7(A)(2) consultation with the USFWS on each of the 66 active ingredients, and the USFWS issues a Biological Opinion including a "not likely to adversely affect" statement for the pesticides. Under the injunction and order, no-use buffer zones of 60 feet for ground applications and 200 feet for aerial applications apply from the edge of the following California red-legged frog habitats as defined by the USFWS and the Center for Biological Diversity: Aquatic Feature, Aquatic Breeding Habitat, Nonbreeding Aquatic Habitat, and Upland Habitat. These habitats are found in 33 counties of California.

A series of documents that define Interim Measures for Use of Pesticides for various counties in California have been prepared by the CDFA. Interim measures have been defined for all of the counties in the Program Area.

2.5.2 State

2.5.2.1 Porter-Cologne Water Quality Control Act of 1970

This law provides the California State Water Resources Control Board (SWRCB) and the nine Regional Water Quality Control Boards (RWQCBs) with authority to establish Water Quality Control Plans (Basin Plans) that are reviewed and revised periodically. The SWRCB and the RWQCBs carry out the Federal Clean Water Act, including the National Pollutant Discharge Elimination System (NPDES) permitting process for point source discharges and the CWA Section 303 water quality standards program. The administering agencies are the SWRCB and the RWQCBs.

2.5.2.2 California Fish and Wildlife Code Section 1600 et seq.

This law provides for protection and conservation of fish and wildlife resources with respect to any project that may substantially divert or obstruct the natural flow of, or substantially change or use any material from the bed, channel, or bank of any river, stream, or lake. The administering agency is the California Department of Fish and Wildlife (CDFW).

[1] "Disturb means to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, (1) injury to an eagle, (2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or (3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior.''

2.5.2.3 California Endangered Species Act of 1984 (California Fish and Wildlife Code Sections 2050 2098)

This law provides for the protection and management of species and subspecies listed by the State of California as endangered or threatened, or designated as candidates for such listing. They are listed at 14 CCR Section 670.5. This law prohibits "take" of state-listed or candidate species, except as otherwise authorized by the Fish and Wildlife Code. (The term "take" is defined by Section 86 of the Fish and Wildlife Code as "hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill." This definition is different in some respects from the definition of "take" under the Federal Endangered Species Act.) The administering agency is the CDFW.

2.5.2.4 California Fish and Wildlife Code §3503

This law prohibits take, possession, or needless destruction of any bird egg or nest, except as otherwise provided by the Fish and Wildlife Code or regulation made pursuant thereto. The administering agency is the CDFW.

2.5.2.5 California Fish and Wildlife Code §3503.5

This law prohibits take, possession, or destruction of any bird of prey (birds in the order of Falconiformes or Strigiformes), except as otherwise provided by the Fish and Wildlife Code or regulation adopted pursuant thereto. The administering agency is the CDFW.

2.5.2.6 California Fish and Wildlife Code §3511, 4700, and 5050

These laws prohibit take or possession of birds, mammals, and reptiles listed as "fully protected," except as provided by the Fish and Wildlife Code. The administering agency is the CDFW.

2.5.2.7 California Fish and Wildlife Code Section 5650

This law protects water quality from substances or materials deleterious to fish, plant life, or bird life. It prohibits such substances or materials from being placed in waters or places where they can pass into waters of the state, except as authorized pursuant to, and in compliance with, the terms and conditions of permits or authorizations of the State Water Resources Control Board or a Regional Water Quality Control Board such as a waste discharge requirement issued pursuant to California Water Code Section 13263, a waiver issued pursuant to Water Code Section 13269(a), or permit pursuant to Water Code Section 13160. The administering agency for Fish and Wildlife Code Section 5650 is the CDFW.

2.5.2.8 Natural Community Conservation Planning Act (California Fish and Wildlife Code §2800 to 2835)

This law provides for the development of Natural Community Conservation Plans (NCCP) to provide for regional or area-wide protection and perpetuation of natural wildlife diversity, while allowing compatible and appropriate development and growth. The administering agency is the CDFW.

2.5.2.9 Native Plant Protection Act; California Fish and Wildlife Code §1900 et seq.

This law provides for the preservation, protection, and enhancement of endangered or rare native plants of the state. The Native Plant Protection Act allows for the designation of endangered and rare native plant species and states that no person shall take any native plant, or any part or product thereof that the commission has determined to be an endangered native plant or rare native plant, except as otherwise provided in the act. The administering agency is the CDFW.

2.5.2.10 California Food and Agricultural Code, Section(s) 12976 and Section(s) 12981

This code states that no pesticide application should be made or continued when a reasonable possibility exists of damage to nontarget crops, animals, or other public or private property. The administering agency for the above authority is the California Department of Pesticide Regulation (CDPR).

2.5.2.11 California Food and Agricultural Code, Section(s) 29102

This code provides for the protection of bees from pesticide use through notification of beekeepers and the establishment of citrus bee protection areas. Prohibited applications to citrus within a citrus/bee protection area include any pesticide toxic to bees, except those exempted in a subsequent subsection during a citrus bloom period, unless the need for control of lepidoptera larvae or citrus thrips has been established by written recommendation of a representative of the University of California, Agricultural Extension Service, or a licensed agricultural pest control adviser. The recommendation should state either that the citrus planting does not meet the citrus bloom period criteria, or why alternatives less hazardous to bees would not be effective. The administering agency for the above authority is the CDPR.

2.5.3 Local

Local governing bodies may pass ordinances that regulate or restrict pesticide use within their jurisdictional areas. For example, a city council may pass an ordinance that restricts pesticide use in municipal buildings and in public parks, and a school district board can decree that certain pesticides cannot be used in schools. Local governing bodies may pass ordinances that regulate or restrict pesticide use in their own operations. However, these restrictions do not apply to state operations and would not be applicable to treatments proposed by the Districts under the Program because California state law preempts local regulation and restriction of pesticide use. The individual districts will work with the local entities and property owners to implement best management practices for the protection of public health.

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Integrated Mosquito and Vector Management Programs

ATTACHMENT A

LIST OF SPECIAL-STATUS SPECIES OCCURRING IN THE PROGRAM AREAS

Table A-1 CNDDB Occurrences for Special-status Plant Species by District and Adjacent Program Areas

Species Name	Status	Habitat	AM1	AM2	AV1	AV2	CC1	CC2	MS1	MS2	NC1	NC2	NS1	NS2	SC1	SC2	SM1	SM2	So1	So2
bristlecone fir *Abies bracteata*	RPR, 1B	lower montane coniferous forest. rocky sites in Monterey and San Luis Obispo Counties. 210-1600 m.												●						
pink sand-verbena *Abronia umbellata* var. *breviflora*	RPR, 1B	coastal dunes and coastal strand. foredunes and interdunes with sparse cover. Abronia umbellata var. breviflora is usually the plant closest to the ocean. 0-12 m.							●	●		●								
San Mateo thorn-mint *Acanthomintha duttonii*	FE, SE, RPR, 1B	chaparral, valley and foothill grassland, coastal scrub. extant populations only known from very uncommon serpentinite vertisol clays; in relatively open areas. 50-200 m.														●	●			
red-flowered bird's-foot-trefoil *Acmispon rubriflorus*	RPR, 1B	valley and foothill grassland, cismontane woodland. most recent sighting from sterile, red soils-volcanic mudflow deposits. 200-425 m.														●				
Blasdale's bent grass *Agrostis blasdalei*	RPR, 1B	coastal dunes, coastal bluff scrub, coastal prairie. includes agrostis blasdalei var. marinensis, state-listed rare. sandy or gravelly soil close to rocks; often in nutrient-poor soil with sparse vegetation. 5-150 m.							●	●		●		●		●	●	●		
Henderson's bent grass *Agrostis hendersonii*	RPR 3	valley and foothill grassland, vernal pools. little information exists; moist places in grassland or vernal pool habitat. 70-305 m.														●				
vernal pool bent grass *Agrostis lacuna-vernalis*	RPR, 1B	vernal pools. in mima mound areas or on the margins of vernal pools. 115-145 m.												●						
grass alisma *Alisma gramineum*	RPR 2	marshes and swamps. freshwater marsh. 390-1800 m.								●										
Hickman's onion *Allium hickmanii*	RPR, 1B	closed-cone coniferous forest, chaparral, coastal scrub, valley and foothill grassland, coastal prairie. sandy loam, damp ground and vernal swales; mostly in grassland though can be assoc. with chaparral or woodland. 20-200 m											●	●						
Franciscan onion *Allium peninsulare* var. *franciscanum*	RPR, 1B	cismontane woodland, valley and foothill grassland. clay soils; often on serpentine. dry hillsides. 100-300 m.							●	●		●				●	●			
Sharsmith's onion *Allium sharsmithiae*	RPR, 1B	cismontane woodland. rocky, serpentine slopes. 400-1200 m.	●		●			●	●			●				●				
Sonoma alopecurus *Alopecurus aequalis* var. *sonomensis*	FE, RPR, 1B	freshwater marshes and swamps, riparian scrub. wet areas, marshes, and riparian banks with other wetland species. 5-360 m.							●			●								
Napa false indigo *Amorpha californica* var. *napensis*	RPR, 1B	broadleafed upland forest, chaparral, cismontane woodland. openings in forest or woodland or in chaparral. 150-2000 m							●	●	●	●		●						●
large-flowered fiddleneck *Amsinckia grandiflora*	FE, SE, RPR, 1B	cismontane woodland, valley and foothill grassland. annual grassland in various soils. 275-550 m.	●	●	●	●	●	●								●				
bent-flowered fiddleneck *Amsinckia lunaris*	RPR, 1B	cismontane woodland, valley and foothill grassland. 50-500 m.	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●		●
scabrid alpine tarplant *Anisocarpus scabridus*	RPR, 1B	upper montane coniferous forest. open stony ridges, metamorphic scree slopes of mountain peaks, and cliffs in or near red fir forest. 1650-2300 m.								●		●								
slender silver moss *Anomobryum julaceum*	RPR 2	broadleafed upland forest, lower montane coniferous forest, north coast coniferous forest. moss, which grows on damp rocks and soil; acidic substrates. usually seen on roadcuts. 100-1000 m.		●		●	●		●			●		●		●		●		

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Species Name	Status	Habitat	AM1	AM2	AV1	AV2	CC1	CC2	MS1	MS2	NC1	NC2	NS1	NS2	SC1	SC2	SM1	SM2	So1	So2
McDonald's rockcress *Arabis mcdonaldiana*	FE, SE, RPR, 1B	lower montane coniferous forest, upper montane coniferous forest. rocky outcrops, ridges, slopes, and flats on serpentine. 135-1455 m.								●										
Anderson's manzanita *Arctostaphylos andersonii*	RPR, 1B	broadleaved upland forest, chaparral, north coast coniferous forest. open sites, redwood forest. 180-800 m.		●		●								●	●	●	●	●		
Mt. Diablo manzanita *Arctostaphylos auriculata*	RPR, 1B	chaparral. in canyons and on slopes. on sandstone. 120-500 m.		●		●	●													
Baker's manzanita *Arctostaphylos bakeri* ssp. *bakeri*	SR, RPR, 1B	broadleafed upland forest, chaparral. entire species state-listed rare. often on serpentine. this is the state-listed rare taxon, also known as a. bakeri in title 14. 75-230 m.							●			●								
The Cedars manzanita *Arctostaphylos bakeri* ssp. *sublaevis*	SR, RPR, 1B	chaparral, closed-cone coniferous forest. entire species listed state rare. in serpentine chaparral and sargent cypress woodland; typically in canyons and on slopes. 275-600 m.							●			●								
Sonoma canescent manzanita *Arctostaphylos canescens* ssp. *sonomensis*	RPR, 1B	chaparral, lower montane coniferous forest. sometimes found on serpentine. 180-1700 m.							●	●		●								
Arroyo de la Cruz manzanita *Arctostaphylos cruzensis*	RPR, 1B	broadleafed upland forest, coastal bluff scrub, closed-cone coniferous forest, chaparral, coastal scrub, and grassland. on sandy soils in several different habitat types from chaparral to coastal scrub to woodland. 60-310 m.							●			●		●						
Vine Hill manzanita *Arctostaphylos densiflora*	SE, RPR, 1B	chaparral. acid marine sand. 50-100 m.							●			●								
Little Sur manzanita *Arctostaphylos edmundsii*	RPR, 1B	coastal bluff scrub, chaparral. includes a. edmundsii var. parvifolia, state-listed rare. forming mounds on sandy terraces on ocean bluffs. 30-105 m.												●						
Franciscan manzanita *Arctostaphylos franciscana*	RPR, 1B	chaparral. serpentine outcrops in chaparral. 60-300 m.																●		
Gabilan Mountains manzanita *Arctostaphylos gabilanensis*	RPR, 1B	chaparral, cismontane woodland. grainitic substrates. 300-700 m.											●	●		●				
Schreiber's manzanita *Arctostaphylos glutinosa*	RPR, 1B	closed-cone coniferous forest, chaparral. mudstone or diatomaceous shale outcrops; often with pinus attenuata. 170-690 m.												●		●		●		
Hooker's manzanita *Arctostaphylos hookeri* ssp. *hookeri*	RPR, 1B	chaparral, coastal scrub, closed-cone coniferous forest, cismontane woodland. sandy soils, sandy shales, sandstone outcrops. 85-300 m.											●	●		●		●		
San Bruno Mountain manzanita *Arctostaphylos imbricata*	SE, RPR, 1B	chaparral, coastal scrub. mostly known from a few sandstone outcrops in chaparral. 275-365 m.														●	●			
Konocti manzanita *Arctostaphylos manzanita* ssp. *elegans*	RPR, 1B	chaparral, cismontane woodland, lower montane coniferous forest. volcanic soils. 395-1400 m.							●	●	●	●								●
Contra Costa manzanita *Arctostaphylos manzanita* ssp. *laevigata*	RPR, 1B	chaparral. rocky slopes. 500-1100 m.		●		●	●													
Mt. Tamalpais manzanita *Arctostaphylos montana* ssp. *montana*	RPR, 1B	chaparral, valley and foothill grassland. serpentine slopes in chaparral and grassland. 160-760 m.							●			●								

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Presidio manzanita *Arctostaphylos montana* ssp. *ravenii*	FE, SE, RPR, 1B	chaparral, coastal prairie, coastal scrub. open, rocky serpentine slopes. 20-215 m.																●		
Montara manzanita *Arctostaphylos montaraensis*	RPR, 1B	chaparral, coastal scrub. slopes and ridges. 150-500 m.														●	●			
Toro manzanita *Arctostaphylos montereyensis*	RPR, 1B	chaparral, cismontane woodland, coastal scrub. sandy soil, usually with chaparral associates. 30-730 m.											●	●						
pygmy manzanita *Arctostaphylos nummularia* ssp. *mendocinoensis*	RPR, 1B	closed-cone coniferous forest. acidic, sandy-clay soils in dwarf coniferous forest. 90-200 m.								●										
Ohlone manzanita *Arctostaphylos ohloneana*	RPR, 1B	coastal scrub, closed cone coniferous forests. Monterey shale. 450-530 m.												●		●		●		
Pacific manzanita *Arctostaphylos pacifica*	SE, RPR, 1B	coastal scrub.																		
Pajaro manzanita *Arctostaphylos pajaroensis*	RPR, 1B	chaparral. sandy soils. 30-760 m.											●	●		●		●		
pallid manzanita *Arctostaphylos pallida*	FT, SE, RPR, 1B	broadleafed upland forest, closed-cone coniferous forest, chaparral, cismontane woodland, coastal scrub. grows on uplifted marine terraces on siliceous shale or thin chert. may require fire. 185-465 m.	●	●	●	●	●	●								●				
sandmat manzanita *Arctostaphylos pumila*	RPR, 1B	closed-cone coniferous forest, chaparral, cismontane woodland, coastal dunes, coastal scrub. on sandy soil with other chaparral associates. 3-205 m.											●	●						
Kings Mountain manzanita *Arctostaphylos regismontana*	RPR, 1B	broadleaved upland forest, chaparral, north coast coniferous forest. granitic or sandstone outcrops. 305-730 m.		●		●								●	●	●	●	●		
Bonny Doon manzanita *Arctostaphylos silvicola*	RPR, 1B	chaparral, closed-cone coniferous forest, lower montane coniferous forest. only known from zayante (inland marine) sands in Santa Cruz County. 120-390 m.												●		●		●		
Rincon Ridge manzanita *Arctostaphylos stanfordiana* ssp. *decumbens*	RPR, 1B	chaparral. highly restricted endemic to red rhyolites in Sonoma County. 75-310 m.							●	●	●	●								●
Raiche's manzanita *Arctostaphylos stanfordiana* ssp. *raichei*	RPR, 1B	chaparral, lower montane coniferous forest. on periphery of mcnab cypress grove on serpentine. slopes and ridges. 450-1000 m.								●		●								
Marin manzanita *Arctostaphylos virgata*	RPR, 1B	broadleafed upland forest, closed-cone coniferous forest, chaparral, north coast coniferous forest. only known from about 20 eos in Marin County. on sandstone or granitic soil. 60-700 m.							●			●								
marsh sandwort *Arenaria paludicola*	FE, SE, RPR, 1B	marshes and swamps. growing up through dense mats of typha, juncus, scirpus, etc. in freshwater marsh. 10-170 m.												●		●		●		
Indian Valley spineflower *Aristocapsa insignis*	RPR, 1B	cismontane woodland. 300-600 m.												●						
Humboldt milk-vetch *Astragalus agnicidus*	SE, RPR, 1B	broadleafed upland forest, redwood forest. disturbed openings in partially timbered forest lands; also along ridgelines; south aspects. 575-750 m.								●										

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Clara Hunt's milk-vetch *Astragalus claranus*	FE, ST, RPR, 1B	cismontane woodland, valley and foothill grassland, chaparral. open grassy hillsides, esp. on exposed shoulders in thin, volcanic clay soil moist in spring. 75-235 m.							●	●	●	●								●
coastal marsh milk-vetch *Astragalus pycnostachyus* var. *pycnostachyus*	RPR, 1B	coastal dunes, coastal salt marshes. mesic sites in dunes or along streams or coastal salt marshes. 0-30 m.							●			●				●	●			
Jepson's milk-vetch *Astragalus rattanii* var. *jepsonianus*	RPR, 1B	cismontane woodland, valley and foothill grassland, chaparral. commonly on serpentine in grassland or openings in chaparral. 320-700 m.								●	●	●								●
Ferris' milk-vetch *Astragalus tener* var. *ferrisiae*	RPR, 1B	meadows, valley and foothill grassland. subalkaline flats on overflow land in the Central Valley; usually seen in dry, adobe soil. 5-75 m.										●								●
alkali milk-vetch *Astragalus tener* var. *tener*	RPR, 1B	alkali playa, valley and foothill grassland, vernal pools. low ground, alkali flats, and flooded lands; in annual grassland or in playas or vernal pools. 1-170 m.	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●		●
coastal dunes milk-vetch *Astragalus tener* var. *titi*	FE, SE, RPR, 1B	coastal bluff scrub, coastal dunes. moist, sandy depressions of bluffs or dunes along and near the pacific ocean; one site on a clay terrace. 1-50 m.												●						
heartscale *Atriplex cordulata* var. *cordulata*	RPR, 1B	chenopod scrub, valley and foothill grassland, meadows. alkaline flats and scalds in the Central Valley, sandy soils. 1-150(600)m.	●	●	●	●	●	●				●				●				●
Lost Hills crownscale *Atriplex coronata* var. *vallicola*	RPR, 1B	chenopod scrub, valley and foothill grassland, vernal pools. in powdery, alkaline soils that are vernally moist with frankenia, atriplex spp. and distichlis. 0-605 m.														●				
brittlescale *Atriplex depressa*	RPR, 1B	chenopod scrub, meadows, playas, valley and foothill grassland, vernal pools. usually in alkali scalds or alk. clay in meadows or annual grassland; rarely associate with riparian, marshes, or v.p's. 1-320 m.	●	●	●	●	●	●				●				●				●
San Joaquin spearscale *Atriplex joaquinana*	RPR, 1B	chenopod scrub, alkali meadow, valley and foothill grassland. in seasonal alkali wetlands or alkali sink scrub with distichlis spicata, frankenia, etc. 1-250 m.	●	●	●	●	●	●		●	●	●		●	●	●		●	●	●
lesser saltscale *Atriplex minuscula*	RPR, 1B	chenopod scrub, playas, valley and foothill grassland. in alkali sink and grassland in sandy, alkaline soils. 20-100 m.	●		●			●								●				
vernal pool smallscale *Atriplex persistens*	RPR, 1B	vernal pools. alkaline vernal pools. 10-115 m.										●				●			●	
subtle orache *Atriplex subtilis*	RPR, 1B	valley and foothill grassland. little info available. madrono vol. 44 no. 2 only source currently. 40-100 m.														●				
San Simeon baccharis *Baccharis plummerae* ssp. *glabrata*	RPR, 1B	coastal scrub. in open shrub-grassland associations. 90-375 m.												●						
big-scale balsamroot *Balsamorhiza macrolepis*	RPR, 1B	valley and foothill grassland, cismontane woodland. sometimes on serpentine. 35-1000 m.	●	●	●	●		●	●	●	●	●			●	●		●	●	●
Sonoma sunshine *Blennosperma bakeri*	FE, SE, RPR, 1B	vernal pools, valley and foothill grassland. vernal pools and swales. 10-100 m.							●			●								
Point Reyes blennosperma *Blennosperma nanum* var. *robustum*	SR, RPR, 1B	coastal prairie, coastal scrub. on open coastal hills in sandy soil. 10-145 m.							●	●		●								

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big tarplant *Blepharizonia plumosa*	RPR, 1B	valley and foothill grassland. dry hills and plains in annual grassland. clay to clay-loam soils; usually on slopes and often in burned areas. 15-455 m.	●	●	●	●	●	●				●				●			●	
Mount Day rockcress *Boechera rubicundula*	RPR, 1B	chaparral. rocky slopes. 1200 m.													●			●		
Snow Mountain rockcress *Boechera ultraalsa*	RPR, 1B	upper montane coniferous forest. rocky sites. 1800 m.								●		●								
rattlesnake fern *Botrypus virginianus*	RPR 2	bogs and fens, lower montane coniferous forest, meadows and seeps, riparian forest. 715-1355 m.								●										
watershield *Brasenia schreberi*	RPR 2	freshwater marshes and swamps. aquatic from water bodies both natural and artificial in California.		●		●		●		●		●								●
narrow-anthered brodiaea *Brodiaea leptandra*	RPR, 1B	broadleafed upland forest, chaparral, lower montane coniferous forest. 110-915 m.							●	●	●	●								●
Indian Valley brodiaea *Brodiaea rosea*	SE, RPR, 1B	closed-cone coniferous forest, chaparral, cismontane woodland, valley and foothill grassland, meadows. serpentine gravelly creek bottoms, and in meadows and swales. 335-1450 m.								●		●								
Thurber's reed grass *Calamagrostis crassiglumis*	RPR 2	coastal scrub, freshwater marsh. usually in marshy swales surrounded by grassland or coastal scrub. 10-45 m.							●	●		●								
leafy reed grass *Calamagrostis foliosa*	SR, RPR 4	coastal bluff scrub, north coast coniferous forest. rocky cliffs and ocean-facing bluffs. 0-1220 m. state-listed rare. element occurrences archived; cnps list 4.								●										
round-leaved filaree *California macrophylla*	RPR, 1B	cismontane woodland, valley and foothill grassland. clay soils. 15-1200 m.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
late-flowered mariposa-lily *Calochortus fimbriatus*	RPR, 1B	chaparral, cismontane woodland. dry, open coastal woodland, chaparral; on serpentine. 270-1910 m.												●						
Mt. Diablo fairy-lantern *Calochortus pulchellus*	RPR, 1B	chaparral, cismontane woodland, riparian woodland, valley and foothill grassland. on wooded and brushy slopes. 200-800 m.	●	●	●	●	●	●								●				
The Cedars fairy-lantern *Calochortus raichei*	RPR, 1B	closed-cone coniferous forest, chaparral. on serpentine. usually on shaded slopes, but also on barrens and talus. 200-490 m.							●			●								
Tiburon mariposa-lily *Calochortus tiburonensis*	FT, ST, RPR, 1B	valley and foothill grassland. on open, rocky, slopes in serpentine grassland. 50-150 m.							●	●	●	●								●
Hoover's calycadenia *Calycadenia hooveri*	RPR, 1B	cismontane woodland, valley and foothill grassland. on exposed, rocky, barren soil. 65-260 m.														●				
small-flowered calycadenia *Calycadenia micrantha*	RPR, 1B	chaparral, valley and foothill grassland, meadows and seeps, lower montane coniferous forest. rocky talus or scree; sparsely vegetated areas. occasionally on roadsides; sometimes on serpentine. 5-1500 m.								●		●		●						
dwarf calycadenia *Calycadenia villosa*	RPR, 1B	chaparral, cismontane woodland, valley and foothill grassland, meadows and seeps. open, dry meadows, hillsides, gravelly outwashes. 215-1275 m.																		
Santa Cruz Mountains pussypaws *Calyptridium parryi* var. *hesseae*	RPR, 1B	chaparral, cismontane woodland. sandy or gravelly openings. 305-1530 m.		●		●								●	●	●		●		
coast range bindweed *Calystegia collina* ssp. *tridactylosa*	RPR, 1B	chaparral, cismontane woodland. rocky, gravelly openings in serpentine. 0-600 m.								●		●								

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coastal bluff morning-glory *Calystegia purpurata* ssp. *saxicola*	RPR, 1B	coastal dunes, coastal scrub. 15-105 m.		●		●	●		●	●		●								
San Benito evening-primrose *Camissonia benitensis*	FT, RPR, 1B	chaparral, cismontane woodland. on gravelly serpentine alluvial terraces. 750-1280 m.												●		●				
Hardham's evening-primrose *Camissoniopsis hardhamiae*	RPR, 1B	chaparral, cismontane woodland. decomposed carbonate. 330-500 m.												●						
swamp harebell *Campanula californica*	RPR, 1B	bogs and fens, closed-cone coniferous forest, coastal prairie, meadows, freshwater marsh, n coast coniferous forest. bogs and marshes in a variety of habitats; uncommon where it occurs. 1-405 m.							●	●		●				●		●		
chaparral harebell *Campanula exigua*	RPR, 1B	chaparral. rocky sites, usually on serpentine in chaparral. 300-1250 m.	●	●	●	●	●	●						●	●	●		●		
Sharsmith's harebell *Campanula sharsmithiae*	RPR, 1B	chaparral. serpentine barrens. 490-855 m.		●		●									●	●		●		
seaside bittercress *Cardamine angulata*	RPR 2	north coast coniferous forest, lower montane coniferous forest. wet areas, streambanks. 65-915 m.																		
white sedge *Carex albida*	FE, SE, RPR, 1B	freshwater marsh, bogs and fens, meadows and seeps. wet meadows and marshes. 35-55 m.							●			●								
California sedge *Carex californica*	RPR 2	bogs and fens, closed-cone coniferous forest, coastal prairie, meadows, marshes and swamps. meadows, drier areas of swamps, marsh margins. 90-250 m.								●										
bristly sedge *Carex comosa*	RPR 2	marshes and swamps. lake margins, wet places; site below sea level is on a delta island. -5-1005 m.		●		●	●	●	●	●		●		●		●	●	●		●
porcupine sedge *Carex hystericina*	RPR 2	marshes and swamps. wet places, such as stream edges. 610-915 m.								●		●								
Klamath sedge *Carex klamathensis*	RPR, 1B	meadows and seeps, chaparral, cismontane woodland. serpentine. 1000-1140 m.								●		●								
lagoon sedge *Carex lenticularis* var. *limnophila*	RPR 2	bogs and fens, marshes and swamps, north coast coniferous forest. lakeshores, beaches. 0-6 m.								●										
bristle-stalked sedge *Carex leptalea*	RPR 2	bogs and fens, meadows, marshes and swamps. mostly known from bogs and wet meadows. 0-790 m.																		
livid sedge *Carex livida*	RPR 1A	bogs and fens. historically known from a sphagnum bog in California. 120 m.							●	●		●								
Lyngbye's sedge *Carex lyngbyei*	RPR 2	marshes and swamps (brackish or freshwater). 0 m.							●	●		●								
San Luis Obispo sedge *Carex obispoensis*	RPR, 1B	closed-cone coniferous forest, chaparral, coastal prairie, coastal scrub, valley and foothill grassland. usually in transition zone on sand, clay, or serpentine; in seeps. 5-790 m.												●						
deceiving sedge *Carex saliniformis*	RPR, 1B	coastal prairie, coastal scrub, meadows and seeps, marshes and swamps (coastal salt). mesic sites. 3-230 m.							●	●		●		●		●		●		
green yellow sedge *Carex viridula* ssp. *viridula*	RPR 2	bogs and fens, marshes and swamps (freshwater), north coast coniferous forest. mesic sites. 0-1600 m.								●										

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Muir's tarplant *Carlquistia muirii*	RPR, 1B	chaparral, lower montane coniferous forest, upper montane coniferous forest. crevices of granite ledges and dry sandy soils. 1100-2500 m.												●						
Oregon coast paintbrush *Castilleja affinis* ssp. *litoralis*	RPR 2	coastal bluff scrub, coastal dunes, coastal scrub. sandy sites. 15-100 m.								●										
Tiburon paintbrush *Castilleja affinis* ssp. *neglecta*	FE, ST, RPR, 1B	valley and foothill grassland. rocky serpentine sites. 75-400 m.		●		●			●	●	●	●			●			●		●
Humboldt Bay owl's-clover *Castilleja ambigua* ssp. *humboldtiensis*	RPR, 1B	coastal salt marsh. in coastal saltmarsh with spartina, distichlis, salicornia, jaumea. 0-3 m.							●	●		●								
pink johnny-nip *Castilleja ambigua* ssp. *insalutata*	RPR, 1B	coastal bluff scrub, coastal prairie. 0-100 m.											●	●						
succulent owl's-clover *Castilleja campestris* ssp. *succulenta*	FT, SE, RPR, 1B	vernal pools, valley and foothill grassland. moist places, often in acidic soils. 25-750 m.		●		●		●								●				
Mendocino Coast paintbrush *Castilleja mendocinensis*	RPR, 1B	coastal bluff scrub, coastal scrub, coastal prairie, closed-cone coniferous forest, coastal dunes. often on sea bluffs or cliffs in coastal bluff scrub or prairie. 0-160 m.							●	●		●								
pink creamsacs *Castilleja rubicundula* ssp. *rubicundula*	RPR, 1B	chaparral, meadows and seeps, valley and foothill grassland. openings in chaparral or grasslands. on serpentine. 20-900 m.		●		●				●	●	●			●			●		●
Pitkin Marsh paintbrush *Castilleja uliginosa*	SE, RPR 1A	freshwater marsh. last known remaining plant died in 1987; was known from overgrown freshwater marsh. 60 m.							●			●								
Lemmon's jewel-flower *Caulanthus lemmonii*	RPR, 1B	pinyon-juniper woodland, valley and foothill grassland. 80-1220 m.	●	●	●	●		●						●		●				
Rincon Ridge ceanothus *Ceanothus confusus*	RPR, 1B	closed-cone coniferous forest, chaparral, cismontane woodland. known from volcanic or serpentine soils, dry shrubby slopes. 75-1065 m.							●	●	●	●								●
Calistoga ceanothus *Ceanothus divergens*	RPR, 1B	chaparral, cismontane woodland. rocky, serpentine or volcanic sites. 165-950 m.							●	●	●	●								●
Coyote ceanothus *Ceanothus ferrisiae*	FE, RPR, 1B	chaparral, valley and foothill grassland, coastal scrub. serpentine sites in the Mt. Hamilton range. 120-455 m.		●		●									●			●		
Vine Hill ceanothus *Ceanothus foliosus* var. *vineatus*	RPR, 1B	chaparral. sandy, acidic soil in chaparral. 45-85 m.							●			●								
Mt. Vision ceanothus *Ceanothus gloriosus* var. *porrectus*	RPR, 1B	closed-cone coniferous forest, coastal prairie, coastal scrub, valley and foothill grassland. low shrub in a variety of habitats on Pt. Reyes; sandy soils. 25-305 m.							●			●								
Mason's ceanothus *Ceanothus masonii*	SR, RPR, 1B	chaparral. serpentine ridges or slopes in chaparral or transition zone. 230-500 m.							●			●								
holly-leaved ceanothus *Ceanothus purpureus*	RPR, 1B	chaparral. rocky, volcanic slopes. 120-640 m.							●	●	●	●							●	●
Sonoma ceanothus *Ceanothus sonomensis*	RPR, 1B	chaparral. sandy, serpentine or volcanic soils. 210-800 m.							●	●	●	●								●
Congdon's tarplant *Centromadia parryi* ssp. *congdonii*	RPR, 1B	valley and foothill grassland. alkaline soils, sometimes described as heavy white clay. 1-230 m.	●	●	●	●	●	●				●	●	●	●	●	●	●	●	

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pappose tarplant *Centromadia parryi* ssp. *parryi*	RPR, 1B	coastal prairie, meadows and seeps, coastal salt marsh, valley and foothill grassland. vernally mesic, often alkaline sites. 2-420 m.							●	●	●	●				●	●		●	●
Hoover's spurge *Chamaesyce hooveri*	FT, RPR, 1B	vernal pools, valley and foothill grassland. vernal pools on volcanic mudflow or clay substrate. 25-130 m.														●				
dwarf soaproot *Chlorogalum pomeridianum* var. *minus*	RPR, 1B	chaparral, valley and foothill grassland. serpentine. 240-970 m.							●	●		●								
Santa Lucia purple amole *Chlorogalum purpureum* var. *purpureum*	FT, RPR, 1B	cismontane woodland, valley and foothill grassland. often in grassy areas with blue oaks in foothill woodland. 300-330 m.												●						
Point Reyes bird's-beak *Chloropyron maritimum* ssp. *palustre*	RPR, 1B	coastal salt marsh. usually in coastal salt marsh with salicornia, distichlis, jaumea, spartina, etc. 0-15 m.	●	●	●	●		●	●			●			●	●	●	●		
hispid bird's-beak *Chloropyron molle* ssp. *hispidum*	RPR, 1B	meadows, playas, valley and foothill grassland. in damp alkaline soils, especially in alkaline meadows and alkali sinks with distichlis. 10-155 m.	●		●			●				●				●			●	
soft bird's-beak *Chloropyron molle* ssp. *molle*	FE, SR, RPR, 1B	coastal salt marsh. in coastal salt marsh with Distichlis, Salicornia, Frankenia, etc. 0-3 m.		●		●	●	●	●	●	●	●							●	●
palmate-bracted bird's-beak *Chloropyron palmatum*	FE, SE, RPR, 1B	chenopod scrub, valley and foothill grassland. usually on Pescadero silty clay which is alkaline, with Distichlis, Frankenia, etc. 5-155 m.	●	●	●	●		●				●				●				●
Hernandez spineflower *Chorizanthe biloba* var. *immemora*	RPR, 1B	chaparral, cismontane woodland. sandy and gravelly soils on the east slope of the Diablo Range. 695-750 m.												●		●				
Brewer's spineflower *Chorizanthe breweri*	RPR, 1B	chaparral, cismontane woodland, coastal scrub, closed-cone coniferous forest. rocky or gravelly serpentine sites; usually in barren areas. 45-800 m.												●						
San Francisco Bay spineflower *Chorizanthe cuspidata* var. *cuspidata*	RPR, 1B	coastal bluff scrub, coastal dunes, coastal prairie, coastal scrub. closely related to c. pungens. sandy soil on terraces and slopes. 5-550 m.	●		●			●	●			●				●	●	●		
woolly-headed spineflower *Chorizanthe cuspidata* var. *villosa*	RPR, 1B	coastal scrub, coastal dunes, coastal prairie. sandy places near the beach. 3-60 m.							●			●								
Howell's spineflower *Chorizanthe howellii*	FE, ST, RPR, 1B	coastal dunes, coastal prairie, coastal scrub. sand dunes, sandy slopes, and sandy areas in coastal prairie. 0-35 m.								●										
Ben Lomond spineflower *Chorizanthe pungens* var. *hartwegiana*	FE, RPR, 1B	lower montane coniferous forest. zayante coarse sands in maritime ponderosa pine sandhills. 120-470 m.												●		●		●		
Monterey spineflower *Chorizanthe pungens* var. *pungens*	FT, RPR, 1B	coastal dunes, chaparral, cismontane woodland, coastal scrub. sandy soils in coastal dunes or more inland within chaparral or other habitats. 0-150 m.											●	●		●		●		
straight-awned spineflower *Chorizanthe rectispina*	RPR, 1B	chaparral, cismontane woodland, coastal scrub. often on granite in chaparral. 85-1035 m.												●						
Scotts Valley spineflower *Chorizanthe robusta* var. *hartwegii*	FE, RPR, 1B	meadows, valley and foothill grassland. in grasslands with mudstone and sandstone outcrops. 230-245 m.														●		●		

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robust spineflower *Chorizanthe robusta* var. *robusta*	FE, RPR, 1B	cismontane woodland, coastal dunes, coastal scrub. sandy terraces and bluffs or in loose sand. 3-120 m.	●	●	●	●		●	●			●	●	●	●	●	●	●		
Sonoma spineflower *Chorizanthe valida*	FE, SE, RPR, 1B	coastal prairie. sandy soil. 10-50 m.							●			●								
Bolander's water-hemlock *Cicuta maculata* var. *bolanderi*	RPR 2	marshes, fresh or brackish water. 0-200 m.		●		●	●	●				●							●	●
Franciscan thistle *Cirsium andrewsii*	RPR, 1B	coastal bluff scrub, broadleaved upland forest, coastal scrub. sometimes serpentine seeps. 0-135 m.		●		●	●		●			●				●	●	●		
slough thistle *Cirsium crassicaule*	RPR, 1B	chenopod scrub, marshes and swamps, riparian scrub. sloughs, riverbanks, and marshy areas. 3-100 m.		●		●		●												
Mt. Hamilton fountain thistle *Cirsium fontinale* var. *campylon*	RPR, 1B	cismontane woodland, chaparral, valley and foothill grassland. in seasonal and perennial drainages on serpentine. 95-890 m.	●	●	●	●		●							●	●		●		
fountain thistle *Cirsium fontinale* var. *fontinale*	FE, SE, RPR, 1B	valley and foothill grassland, chaparral. serpentine seeps and grassland. 90-180 m.														●	●			
Suisun thistle *Cirsium hydrophilum* var. *hydrophilum*	FE, RPR, 1B	salt marsh. grows with scirpus, distichlis near small watercourses within saltmarsh. 0-1 m.										●							●	
Mt. Tamalpais thistle *Cirsium hydrophilum* var. *vaseyi*	RPR, 1B	broadleafed upland forest, chaparral, meadows and seeps. serpentine seeps and streams in chaparral and woodland. 240-620 m.							●			●								
compact cobwebby thistle *Cirsium occidentale* var. *compactum*	RPR, 1B	chaparral, coastal dunes, coastal prairie, coastal scrub. on dunes and on clay in chaparral; also in grassland. 5-155 m.												●				●		
lost thistle *Cirsium praeteriens*	RPR 1A	little information exists on this plant; it was collected from the Palo Alto area at the turn of the 20th century. although not seen since 1901, this Cirsium is thought to be quite distinct from other Cirsiums according to D. Keil. 0-100 m.		●		●									●	●	●	●		
Whitney's farewell-to-spring *Clarkia amoena* ssp. *whitneyi*	RPR, 1B	coastal bluff scrub, coastal scrub. 10-100 m.								●										
Raiche's red ribbons *Clarkia concinna* ssp. *raichei*	RPR, 1B	coastal bluff scrub. highly exposed rocky bluffs with a near-vertical slope. 0-100 m.							●			●								
Presidio clarkia *Clarkia franciscana*	FE, SE, RPR, 1B	coastal scrub, valley and foothill grassland. serpentine outcrops in grassland or scrub. 20-335 m.	●		●			●								●		●		
Vine Hill clarkia *Clarkia imbricata*	FE, SE, RPR, 1B	chaparral, valley and foothill grassland. acidic, sandy soil. 50-75 m.							●			●								
Jolon clarkia *Clarkia jolonensis*	RPR, 1B	cismontane woodland. 500 m.											●	●						
beaked clarkia *Clarkia rostrata*	RPR, 1B	cismontane woodland, valley and foothill grassland. north-facing slopes; sometimes on sandstone. 60-460 m.														●				
San Antonio collinsia *Collinsia antonina*	RPR, 1B	chaparral, cismontane woodland. shale substrates. 280-365 m.												●						
round-headed Chinese-houses *Collinsia corymbosa*	RPR, 1B	coastal dunes. 0-20 m.																●		

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San Francisco collinsia *Collinsia multicolor*	RPR, 1B	closed-cone coniferous forest, coastal scrub. on decomposed shale (mudstone) mixed with humus. 30-250 m.		●		●			●			●	●	●	●	●	●	●		
Oregon goldthread *Coptis laciniata*	RPR 2	north coast coniferous forest, meadows and seeps. mesic sites such as moist streambanks. 0-1000 m.								●										
Mt. Diablo bird's-beak *Cordylanthus nidularius*	SR, RPR, 1B	chaparral. grassy or rocky areas within serpentine chaparral. 600-800 m.		●		●	●													
seaside bird's-beak *Cordylanthus rigidus* ssp. *littoralis*	SE, RPR, 1B	closed-cone coniferous forest, chaparral, cismontane woodland, coastal scrub, coastal dunes. sandy, often disturbed sites, usually within chaparral or coastal scrub. 0-215 m.											●	●						
Pennell's bird's-beak *Cordylanthus tenuis* ssp. *capillaris*	FE, SR, RPR, 1B	closed-cone coniferous forest, chaparral. in open or disturbed areas on serpentine within forest or chaparral. 45-230 m.							●			●								
serpentine cryptantha *Cryptantha dissita*	RPR, 1B	chaparral. serpentine outcrops. 330-730 m.							●	●	●	●								●
deep-scarred cryptantha *Cryptantha excavata*	RPR, 1B	cismontane woodland. sandy, gravelly, dry streambanks. 100-500 m.								●										
Hoover's cryptantha *Cryptantha hooveri*	RPR 1A	valley and foothill grassland. in coarse sand. ?-150 m.		●		●	●									●				
Mariposa cryptantha *Cryptantha mariposae*	RPR, 1B	chaparral. on serpentine outcrops. 200-650 m.														●				
Jepson's dodder *Cuscuta jepsonii*	RPR, 1B	north coast coniferous forest. streamsides. 1200-2300 m.								●		●								
Peruvian dodder *Cuscuta obtusiflora* var. *glandulosa*	RPR 2	marshes and swamps (freshwater). freshwater marsh. 15-280 m.						●	●			●				●				●
Mendocino dodder *Cuscuta pacifica* var. *papillata*	RPR, 1B	coastal dunes. interdune depressions. annual parasitic vine observed on Gnaphalium, Silene and Lupinus. 0-50 m.							●	●		●								
tear drop moss *Dacryophyllum falcifolium*	RPR, 1B	coast redwood forest, north coast coniferous forest. limestone substrates and rock outcrops. 50-275 m.												●		●		●		
Livermore tarplant *Deinandra bacigalupii*	RPR, 1B	meadows and seeps. alkaline meadows. 150-185 m.	●		●			●								●				
Hall's tarplant *Deinandra halliana*	RPR, 1B	cismontane woodland, chenopod scrub, valley and foothill grassland. reported from a variety of substrates incl. clay, sand, and alkaline soils. 300-950 m.												●		●				
Baker's larkspur *Delphinium bakeri*	FE, SE, RPR, 1B	coastal scrub, grasslands. only site occurs on nw-facing slope, on decomposed shale. historically known from grassy areas along fence lines too. 90-205 m.							●			●								
Hospital Canyon larkspur *Delphinium californicum* ssp. *interius*	RPR, 1B	cismontane woodland, chaparral. in wet, boggy meadows, openings in chaparral and in canyons. 225-1060 m.	●	●	●	●	●	●						●	●	●		●		
Hutchinson's larkspur *Delphinium hutchinsoniae*	RPR, 1B	broadleafed upland forest, chaparral, coastal prairie, coastal scrub. on semi-shaded, slightly moist slopes, usually west-facing. 0-365 m.											●	●						
golden larkspur *Delphinium luteum*	FE, SR, RPR, 1B	chaparral, coastal prairie, coastal scrub. north-facing rocky slopes. 0-100 m.							●			●								

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recurved larkspur *Delphinium recurvatum*	RPR, 1B	chenopod scrub, valley and foothill grassland, cismontane woodland. on alkaline soils; often in valley saltbush or valley chenopod scrub. 3-685 m.	●	●	●	●	●	●				●		●		●			●	
umbrella larkspur *Delphinium umbraculorum*	RPR, 1B	cismontane woodland. mesic sites. 400-1600 m.												●						
Norris' beard moss *Didymodon norrisii*	RPR 2	cismontane woodland, lower montane coniferous forest. moss from seasonally wet sheet drainages on exposed rock slabs or terraces that completely dry in summer. less frequent		●		●	●		●	●		●		●		●		●		
western leatherwood *Dirca occidentalis*	RPR, 1B	broadleafed upland forest, chaparral, closed-cone coniferous forest, cismontane woodland, north coast coniferous forest, riparian forest, riparian woodland. on brushy slopes, mesic sites; mostly in mixed evergreen and foothill woodland communities. 30-550 m.	●	●	●	●	●	●	●			●			●	●	●	●		
dwarf downingia *Downingia pusilla*	RPR 2	valley and foothill grassland (mesic sites), vernal pools. vernal lake and pool margins with a variety of associates. in several types of vernal pools. 1-485 m.		●		●		●	●	●	●	●				●			●	●
Santa Clara Valley dudleya *Dudleya abramsii* ssp. *setchellii*	FE, RPR, 1B	valley and foothill grassland, cismontane woodland. on rocky serpentine outcrops and on rocks within grassland or woodland. 80-335 m.		●		●									●			●		
Koch's cord moss *Entosthodon kochii*	RPR, 1B	cismontane woodland, valley and foothill grasslands. moss growing on soil on river banks. known from serpentine on the plumas nf. 500-1000 m.							●	●		●								
Snow Mountain willowherb *Epilobium nivium*	RPR, 1B	upper montane coniferous forest, chaparral. in crevices of rocky outcrops, and dry talus and shale slopes. 785-2500 m.								●		●								
Oregon fireweed *Epilobium oreganum*	RPR, 1B	bogs and fens, meadows, lower montane coniferous forest, upper montane coniferous forest. in and near springs and bogs; at least sometimes on serpentine. 500-2610 m.								●										
Brandegee's eriastrum *Eriastrum brandegeeae*	RPR, 1B	chaparral, cismontane woodland. on barren volcanic soils; often in open areas. 425-840 m.								●		●								
yellow-flowered eriastrum *Eriastrum luteum*	RPR, 1B	broadleafed upland forest, cismontane woodland, chaparral. on bare sandy decomposed granite slopes. 360-1000 m.												●						
Tracy's eriastrum *Eriastrum tracyi*	SR, RPR 3	chaparral, cismontane woodland. gravelly shale or clay; often in open areas. 315-760 m.		●		●				●		●			●	●		●		
Eastwood's goldenbush *Ericameria fasciculata*	RPR, 1B	closed-cone coniferous forest, chaparral (maritime), coastal scrub, coastal dunes. in sandy openings. 30-275 m.											●	●						
Greene's narrow-leaved daisy *Erigeron greenei*	RPR, 1B	chaparral. serpentine and volcanic substrates, generally in shrubby vegetation. 75-1060 m.							●	●	●	●								●
serpentine daisy *Erigeron serpentinus*	RPR, 1B	chaparral. serpentine seeps. 60-670 m.							●			●								
supple daisy *Erigeron supplex*	RPR, 1B	coastal bluff scrub, coastal prairie. usually in grassy sites. 10-50 m.							●	●		●								
Ione buckwheat *Eriogonum apricum* var. *apricum*	FE, SE, RPR, 1B	chaparral. in gravelly openings on ione formation soil. 80-150 m.						●												●
Butterworth's buckwheat *Eriogonum butterworthianum*	SR, RPR, 1B	chaparral, valley and foothill grassland. dry sandstone outcrops and crevices. 585-740 m.												●						

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The Cedars buckwheat *Eriogonum cedrorum*	RPR, 1B	closed-cone coniferous forest. serpentine. barren rock and talus steep slopes. 365-550 m.							●			●								
Eastwood's buckwheat *Eriogonum eastwoodianum*	RPR, 1B	cismontane woodland. shale, including diatomaceous shale. 500-1000 m.												●						
Kellogg's buckwheat *Eriogonum kelloggii*	FC, SE, RPR, 1B	lower montane coniferous forest, chaparral. rocky, serpentine sites. 925-1220 m.								●										
Tiburon buckwheat *Eriogonum luteolum* var. *caninum*	RPR, 1B	chaparral, valley and foothill grassland, cismontane woodland, coastal prairie. serpentine soils; sandy to gravelly sites. 0-700 m.	●		●			●	●			●				●				
Snow Mountain buckwheat *Eriogonum nervulosum*	RPR, 1B	chaparral. dry serpentine outcrops, balds, and barrens. 300-2100 m.							●	●	●	●								●
Pinnacles buckwheat *Eriogonum nortonii*	RPR, 1B	chaparral, valley and foothill grassland. sandy soils; often on recent burns; western Santa lucias. 390-975 m.											●	●		●				
Ben Lomond buckwheat *Eriogonum nudum* var. *decurrens*	RPR, 1B	chaparral, cismontane woodland, lower montane coniferous forest. ponderosa pine sandhills in Santa Cruz County. 50-800 m.		●		●								●	●	●	●	●		
Antioch Dunes buckwheat *Eriogonum nudum* var. *psychicola*	RPR, 1B	interior dunes. grows on the antioch dunes (interior dune system) with lupinus albifrons, gutierrezia californica, and introduced grasse		●		●	●													
Temblor buckwheat *Eriogonum temblorense*	RPR, 1B	valley and foothill grassland. barren clay or sandstone substrates. 300-1000 m.												●						
Mt. Diablo buckwheat *Eriogonum truncatum*	RPR, 1B	chaparral, coastal scrub, valley and foothill grassland. dry, exposed clay or sandy substrates. 3-350 m.		●		●	●					●							●	
San Mateo woolly sunflower *Eriophyllum latilobum*	FE, SE, RPR, 1B	cismontane woodland. often on roadcuts; found on and off of serpentine. 45-150 m.														●	●			
Hoover's button-celery *Eryngium aristulatum* var. *hooveri*	RPR, 1B	vernal pools. alkaline depressions, vernal pools, roadside ditches and other wet places near the coast. 5-45 m.	●	●	●	●		●						●	●	●	●	●		
Loch Lomond button-celery *Eryngium constancei*	FE, SE, RPR, 1B	vernal pools. volcanic ash flow vernal pools. 625-855 m.							●	●		●								
Tuolumne button-celery *Eryngium pinnatisectum*	RPR, 1B	vernal pools, cismontane woodland, lower montane coniferous forest. volcanic soils; vernal pools and mesic sites within other natural communities. 250-450 m.						●												●
Delta button-celery *Eryngium racemosum*	SE, RPR, 1B	riparian scrub. seasonally inundated floodplain on clay. 3-75 m.		●		●	●	●								●				
spiny-sepaled button-celery *Eryngium spinosepalum*	RPR, 1B	vernal pools, valley and foothill grassland. some sites on clay soil of granitic origin; vernal pools, within grassland. 100-420 m.														●				
sand-loving wallflower *Erysimum ammophilum*	RPR, 1B	chaparral (maritime), coastal dunes, coastal scrub. sandy openings. 0-130 m.											●	●		●	●	●		
Contra Costa wallflower *Erysimum capitatum* var. *angustatum*	FE, SE, RPR, 1B	inland dunes. stabilized dunes of sand and clay near Antioch along the San Joaquin river. 3-20 m.		●		●	●													
Menzies' wallflower *Erysimum menziesii* ssp. *menziesii*	FE, SE, RPR, 1B	coastal dunes. localized on dunes and coastal strand. 0-35 m.								●				●						
Yadon's wallflower *Erysimum menziesii* ssp. *yadonii*	FE, SE, RPR, 1B	coastal dunes. foredunes. 0-15 m.												●						

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Santa Cruz wallflower *Erysimum teretifolium*	FE, SE, RPR, 1B	lower montane coniferous forest, chaparral. inland marine sands (Zayante coarse sand). 120-610 m.											●	●		●		●		
giant fawn lily *Erythronium oregonum*	RPR 2	cismontane woodland, meadows and seeps. openings. sometimes on serpentine; rocky sites. 100-500 m.								●										
coast fawn lily *Erythronium revolutum*	RPR 2	bogs and fens, broadleafed upland forest, north coast coniferous forest. 0-1065 m.								●										
diamond-petaled California poppy *Eschscholzia rhombipetala*	RPR, 1B	valley and foothill grassland. alkaline, clay slopes and flats. 0-975 m.	●	●	●	●	●	●								●				
minute pocket moss *Fissidens pauperculus*	RPR, 1B	north coast coniferous forest. moss growing on damp soil along the coast. in dry streambeds and on stream banks. 10-100 m.							●	●		●		●		●		●		
Hillsborough chocolate lily *Fritillaria biflora* var. *ineziana*	RPR, 1B	cismontane woodland, valley and foothill grassland. probably on serpentine; most recent site is in serpentine grassland. 90-160 m.														●	●			
talus fritillary *Fritillaria falcata*	RPR, 1B	chaparral, cismontane woodland, lower montane coniferous forest. on shale, granite, or serpentine talus. 300-1525 m.	●	●	●	●		●						●	●	●		●		
Marin checker lily *Fritillaria lanceolata* var. *tristulis*	RPR, 1B	coastal bluff scrub, coastal scrub, coastal prairie. occurrences reported from canyons and riparian areas as well as rock outcrops; often on serpentine. 30-300 m.							●			●								
fragrant fritillary *Fritillaria liliacea*	RPR, 1B	coastal scrub, valley and foothill grassland, coastal prairie. often on serpentine; various soils reported though usually clay, in grassland. 3-410 m.	●	●	●	●	●	●	●			●	●	●	●	●	●	●	●	
adobe-lily *Fritillaria pluriflora*	RPR, 1B	chaparral, cismontane woodland, foothill grassland. usually on clay soils; sometimes serpentine. 55-820 m.								●	●	●							●	●
Roderick's fritillary *Fritillaria roderickii*	SE, RPR, 1B	coastal bluff scrub, coastal prairie, valley and foothill grassland. grassy slopes, mesas. 15-610 m.							●	●		●								
San Benito fritillary *Fritillaria viridea*	RPR, 1B	chaparral. serpentine slopes. 200-1525 m.												●		●				
Cone Peak bedstraw *Galium californicum* ssp. *luciense*	RPR, 1B	broadleaved upland forest, lower montane coniferous forest, cismontane woodland. in forest duff or gravelly talus of pine and oak forest, in partial shade. 875-1525 m.												●						
Santa Lucia bedstraw *Galium clementis*	RPR, 1B	lower montane coniferous forest, upper montane coniferous forest. forming soft mats in shady rocky patches; on granite or serpentine; mostly on exposed peaks. 1130-1780 m.												●						
Hardham's bedstraw *Galium hardhamiae*	RPR, 1B	closed-cone coniferous forest. on serpentine with cupressus sargentii. 390-975 m.												●						
Mendocino gentian *Gentiana setigera*	RPR, 1B	lower montane coniferous forest, meadows. meadows, seeps and bogs. usually or always on serpentine. 490-1065 m.								●										
blue coast gilia *Gilia capitata* ssp. *chamissonis*	RPR, 1B	coastal dunes, coastal scrub. 2-200 m.							●			●						●		
Pacific gilia *Gilia capitata* ssp. *pacifica*	RPR, 1B	coastal bluff scrub, coastal prairie, valley and foothill grassland. 5-300 m.								●										
woolly-headed gilia *Gilia capitata* ssp. *tomentosa*	RPR, 1B	coastal bluff scrub. rocky outcrops on the coast. 15-155 m.							●			●								
dark-eyed gilia *Gilia millefoliata*	RPR, 1B	coastal dunes. 2-20 m.							●	●		●						●		

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sand gilia *Gilia tenuiflora* ssp. *arenaria*	FE, ST, RPR, 1B	coastal dunes, coastal scrub, chaparral (maritime), cismontane woodland. bare, wind-sheltered areas often near dune summit or in the hind dunes; 2 records from pleistocene inland dunes. 0-245 m.											●	●		●		●		
delicate bluecup *Githopsis tenella*	RPR, 1B	chaparral, cismontane woodland. mesic sites. 1100-1900 m.												●						
American manna grass *Glyceria grandis*	RPR 2	meadows. wet meadows, ditches, streams, and ponds in valleys and lower elevations in the mountains. 15-1980 m.								●										
Boggs Lake hedge-hyssop *Gratiola heterosepala*	SE, RPR, 1B	marshes and swamps (freshwater), vernal pools. clay soils; usually in vernal pools, sometimes on lake margins. 5-2400 m.		●		●		●		●		●				●			●	●
San Francisco gumplant *Grindelia hirsutula* var. *maritima*	RPR 3	coastal scrub, coastal bluff scrub, valley and foothill grassland. sandy or serpentine slopes, sea bluffs. 15-400 m.														●	●	●		
Guggolz's harmonia *Harmonia guggolziorum*	RPR, 1B	chaparral. open areas on serpentine. 160-195 m.								●										
Hall's harmonia *Harmonia hallii*	RPR, 1B	chaparral. serpentine hills and ridges. open, rocky areas within chaparral. 500-900 m.								●	●	●								●
Diablo helianthella *Helianthella castanea*	RPR, 1B	broadleaved upland forest, chaparral, cismontane woodland, coastal scrub, riparian woodland, valley and foothill grassland. usually in chaparral/oak woodland interface in rocky, azonal soils. often in partial shade. 25-1150 m.	●	●	●	●	●	●	●			●				●	●	●		
white seaside tarplant *Hemizonia congesta* ssp. *congesta*	RPR, 1B	coastal scrub, valley and foothill grassland. grassy valleys and hills, often in fallow fields. 25-200 m.							●	●		●				●	●	●		
short-leaved evax *Hesperevax sparsiflora* var. *brevifolia*	RPR, 1B	coastal bluff scrub, coastal dunes. sandy bluffs and flats. 0-200 m.							●	●		●		●		●	●	●		
Santa Cruz cypress *Hesperocyparis abramsiana* var. *abramsiana*	FE, SE, RPR, 1B	closed-cone coniferous forest, lower montane coniferous forest. restricted to the Santa Cruz mountains, on sandstone and granitic-derived soils; often with p. attenuata, redwoods. 300-800 m.												●		●		●		
Butano Ridge cypress *Hesperocyparis abramsiana* var. *butanoensis*	FE, SE, RPR, 1B	closed-cone coniferous forest, lower montane coniferous forest, chaparral. sandstone. 400-490 m.														●	●			
Gowen cypress *Hesperocyparis goveniana*	FT, RPR, 1B	closed-cone coniferous forest. coastal terraces; usually in sandy soils; sometimes with Monterey pine, bishop pine. 100-125 m.												●						
Monterey cypress *Hesperocyparis macrocarpa*	RPR, 1B	closed-cone coniferous forest. granitic soils. 10-30 m.												●						
pygmy cypress *Hesperocyparis pygmaea*	RPR, 1B	closed-cone coniferous forest. on podzol-like Blacklock soil in pygmy cypress forest community. 35-305 m.							●	●		●								
glandular western flax *Hesperolinon adenophyllum*	RPR, 1B	chaparral, cismontane woodland, valley and foothill grassland. serpentine soils; generally found in serpentine chaparral. 425-1315 m.								●		●								
two-carpellate western flax *Hesperolinon bicarpellatum*	RPR, 1B	serpentine chaparral. serpentine barrens at edge of chaparral. 150-820 m.							●	●	●	●								●

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Brewer's western flax *Hesperolinon breweri*	RPR, 1B	chaparral, cismontane woodland, valley and foothill grassland. often in rocky serpentine soil in serpentine chaparral and serpentine grassland. 30-885 m.		●		●	●			●	●	●							●	●
Marin western flax *Hesperolinon congestum*	FT, ST, RPR, 1B	chaparral, valley and foothill grassland. in serpentine barrens and in serpentine grassland and chaparral. 30-365 m.							●			●				●	●	●		
Lake County western flax *Hesperolinon didymocarpum*	SE, RPR, 1B	chaparral, cismontane woodland, valley and foothill grassland. serpentine soil in open grassland and near chaparral. 330-365 m.								●		●								
drymaria-like western flax *Hesperolinon drymarioides*	RPR, 1B	closed-cone coniferous forest, chaparral, cismontane woodland, valley and foothill grassland. serpentine soils, mostly within chaparral. 390-1000 m.								●	●	●								●
Tehama County western flax *Hesperolinon tehamense*	RPR, 1B	chaparral, cismontane woodland. serpentine barrens in chaparral. 225-1155 m.	●		●			●		●	●	●				●				●
woolly rose-mallow *Hibiscus lasiocarpos* var. *occidentalis*	RPR, 1B	marshes and swamps (freshwater). moist, freshwater-soaked river banks and low peat islands in sloughs; in calif., known from the delta watershed. 0-150 m.		●		●	●	●		●		●							●	●
Loma Prieta hoita *Hoita strobilina*	RPR, 1B	chaparral, cismontane woodland, riparian woodland. serpentine; mesic sites.	●	●	●	●	●	●						●	●	●		●		
Santa Cruz tarplant *Holocarpha macradenia*	FT, SE, RPR, 1B	coastal prairie, valley and foothill grassland. light, sandy soil or sandy clay; often with nonnatives. 10-260 m.	●	●	●	●	●	●	●			●	●	●		●		●		
Bolander's horkelia *Horkelia bolanderi*	RPR, 1B	lower montane coniferous forest, chaparral, meadows, valley and foothill grassland. grassy margins of vernal pools and meadows. 450-850 m.								●		●								
Kellogg's horkelia *Horkelia cuneata* var. *sericea*	RPR, 1B	closed-cone coniferous forest, coastal scrub, chaparral. old dunes, coastal sandhills; openings. 10-200 m.	●		●			●	●			●	●	●		●	●	●		
Point Reyes horkelia *Horkelia marinensis*	RPR, 1B	coastal dunes, coastal prairie, coastal scrub. sandy flats and dunes near coast; in grassland or scrub plant communities. 5-30 m.							●	●		●		●		●	●	●		
thin-lobed horkelia *Horkelia tenuiloba*	RPR, 1B	coastal scrub, chaparral. sandy soils; mesic openings. 45-500 m.							●	●		●								
water howellia *Howellia aquatilis*	FT, RPR 2	freshwater marshes and swamps, lower montane coniferous forest. in clear ponds with other aquatics and surrounded by ponderosa pine forest and sometimes riparian associates. 3-1375 m								●										
California satintail *Imperata brevifolia*	RPR 2	coastal scrub, chaparral, riparian scrub, mojavean scrub, meadows and seeps (alkali). mesic sites, alkali seeps, riparian areas. 0-500 m.								●		●								
Carquinez goldenbush *Isocoma arguta*	RPR, 1B	valley and foothill grassland. alkaline soils, flats, lower hills. on low benches near drainages and on tops and sides of mounds in swale habitat. 1-20 m.		●		●	●					●							●	
Northern California black walnut *Juglans hindsii*	RPR, 1B	riparian forest, riparian woodland. few extant native stands remain; widely naturalized. deep alluvial soil associated with a creek or stream. 0-395 m.		●		●	●	●		●	●	●							●	●
Ahart's dwarf rush *Juncus leiospermus* var. *ahartii*	RPR, 1B	vernal pools. restricted to the edges of vernal pools. 30-100 m.						●												●

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Santa Lucia dwarf rush *Juncus luciensis*	RPR, 1B	vernal pools, meadows, lower montane coniferous forest, chaparral, great basin scrub. vernal pools, ephemeral drainages, wet meadow habitats and streamsides. 300-2040 m.								●	●			●		●				●
knotted rush *Juncus nodosus*	RPR 2	meadows, marshes and swamps. mesic sites and lake margins. 1130-1700 m.														●				
hair-leaved rush *Juncus supiniformis*	RPR 2	marshes and swamps, bogs and fens. 20-100 m.								●										
small groundcone *Kopsiopsis hookeri*	RPR 2	north coast coniferous forest. open woods, shrubby places, generally on gaultheria shallon. 90-885 m.							●	●		●								
forked hare-leaf *Lagophylla dichotoma*	RPR, 1B	valley and foothill grassland, cismontane woodland. in openings. gravelly roadsides to loam soil to dry clay; not known from serpentine. 50-760 m.												●		●				
Burke's goldfields *Lasthenia burkei*	FE, SE, RPR, 1B	vernal pools, meadows and seeps. most often in vernal pools and swales. 15-580 m.							●	●	●	●								●
Baker's goldfields *Lasthenia californica* ssp. *bakeri*	RPR, 1B	closed-cone coniferous forest, coastal scrub. openings. 60-520 m.							●	●		●								
perennial goldfields *Lasthenia californica* ssp. *macrantha*	RPR, 1B	coastal bluff scrub, coastal dunes, coastal scrub. 5-520 m.							●	●		●				●	●			
Contra Costa goldfields *Lasthenia conjugens*	FE, RPR, 1B	valley and foothill grassland, vernal pools, cismontane woodland. extirpated from most of its range; extreme. endangered. vernal pools, swales, low depressions, in open grassy areas. 1-445 m.	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●	●
Coulter's goldfields *Lasthenia glabrata* ssp. *coulteri*	RPR, 1B	coastal salt marshes, playas, valley and foothill grassland, vernal pools. usually found on alkaline soils in playas, sinks, and grasslands. 1-1400 m.										●				●				●
Delta tule pea *Lathyrus jepsonii* var. *jepsonii*	RPR, 1B	freshwater and brackish marshes. often found with typha, aster lentus, rosa calif., juncus spp., scirpus, etc. usually on marsh and slough edges.		●		●	●	●	●	●	●	●							●	●
marsh pea *Lathyrus palustris*	RPR 2	bogs and fens, lower montane coniferous forest, marshes and swamps, north coast coniferous forest, coastal prairie, coastal scrub. moist coastal areas. 1-100 m.								●										
beach layia *Layia carnosa*	FE, SE, RPR, 1B	coastal dunes. hugely reduced in range along California's north coast dunes. on sparsely vegetated, semi-stabilized dunes, usually behind foredunes. 0-75 m.							●			●		●			●	●		
rayless layia *Layia discoidea*	RPR, 1B	chaparral, cismontane woodland, lower montane coniferous forest. on serpentine alluvium and serpentine talus. 785-1585 m.												●		●				
pale-yellow layia *Layia heterotricha*	RPR, 1B	cismontane woodland, pinyon-juniper woodland, valley and foothill grassland. alkaline or clay soils; open areas. 270-1365 (2675)m.												●		●				
Munz's tidy-tips *Layia munzii*	RPR, 1B	chenopod scrub, valley and foothill grassland. hillsides, in white-grey alkaline clay soils, with grasses and chenopod scrub associates. 45-760 m.																		
Colusa layia *Layia septentrionalis*	RPR, 1B	chaparral, cismontane woodland, valley and foothill grassland. scattered colonies in fields and grassy slopes in sandy or serpentine soil. 145-1095 m.							●	●	●	●								●

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legenere *Legenere limosa*	RPR, 1B	vernal pools. many historical occurrences are extirpated. in beds of vernal pools. 1-880 m.	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●
Panoche pepper-grass *Lepidium jaredii* ssp. *album*	RPR, 1B	valley and foothill grassland. white or grey clay lenses on steep slopes; incidental in alluvial fans and washes. clay and gypsum-rich soils. 65-910 m.												●		●				
Heckard's pepper-grass *Lepidium latipes* var. *heckardii*	RPR, 1B	valley and foothill grassland, vernal pools. grassland, and sometimes vernal pool edges. alkaline soils. 3-30 m.						●				●				●			●	●
coast yellow leptosiphon *Leptosiphon croceus*	RPR, 1B	coastal bluff scrub, coastal prairie. 10-150 m.							●			●				●	●			
Jepson's leptosiphon *Leptosiphon jepsonii*	RPR, 1B	chaparral, cismontane woodland. open to partially shaded grassy slopes. on volcanics or the periphery of serpentine substrates. 100-500 m.							●	●	●	●								●
rose leptosiphon *Leptosiphon rosaceus*	RPR, 1B	coastal bluff scrub. 0-100 m.							●			●				●	●	●		
Mt. Hamilton coreopsis *Leptosyne hamiltonii*	RPR, 1B	cismontane woodland. on steep shale talus with open southwestern exposure. 530-1300 m.	●	●	●	●		●							●	●		●		
Crystal Springs lessingia *Lessingia arachnoidea*	RPR, 1B	coastal sage scrub, valley and foothill grassland, cismontane woodland. grassy slopes on serpentine; sometimes on roadsides. 60-200 m.							●			●				●	●			
San Francisco lessingia *Lessingia germanorum*	FE, SE, RPR, 1B	coastal scrub. from remnant dunes. open sandy soils relatively free of competing plants. 20-125 m.														●	●	●		
smooth lessingia *Lessingia micradenia* var. *glabrata*	RPR, 1B	chaparral. serpentine; often on roadsides. 120-485 m.																		
Tamalpais lessingia *Lessingia micradenia* var. *micradenia*	RPR, 1B	chaparral, valley and foothill grassland. usually on serpentine, in serpentine grassland or serpentine chaparral. often on roadsides. 100-305 m.							●			●								
Stebbins' lewisia *Lewisia stebbinsii*	RPR, 1B	upper montane coniferous forest, lower montane coniferous forest. relatively barren exposed ridges and slopes in nutrient poor soils (mostly serpentine). 1680-2050 m.								●										
Mason's lilaeopsis *Lilaeopsis masonii*	SR, RPR, 1B	freshwater and brackish marshes, riparian scrub. tidal zones, in muddy or silty soil formed through river deposition or river bank erosion. 0-10 m.	●	●	●	●	●	●	●	●	●	●				●			●	●
coast lily *Lilium maritimum*	RPR, 1B	closed-cone coniferous forest, coastal prairie, coastal scrub, broadleaved upland forest, north coast coniferous forest. historically in sandy soil, often on raised hummocks or bogs; today mostly in roadside ditches. 10-335 m.							●	●		●								
Pitkin Marsh lily *Lilium pardalinum* ssp. *pitkinense*	FE, SE, RPR, 1B	cismontane woodland, meadows and seeps, freshwater marsh. saturated, sandy soils with grasses and shrubs. 35-65 m.							●			●								
Baker's meadowfoam *Limnanthes bakeri*	RPR, 1B	freshwater marsh, valley and foothill grassland, meadows and seeps, vernal pools. seasonally moist or saturated sites within grassland; also in swales, roadside ditches and margins of marshy areas. 175-910 m								●										

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Point Reyes meadowfoam *Limnanthes douglasii* ssp. *sulphurea*	SE, RPR, 1B	fresh. marsh, vernal pools, coastal prairie, meadows and seeps, cismontane woodland. vernally wet depressions in open rolling, coastal prairies and meadows; typically in dark clay soil. 10-120 m.							●			●				●	●			
Sebastopol meadowfoam *Limnanthes vinculans*	FE, SE, RPR, 1B	mesic meadows, vernal pools, valley and foothill grassland. swales, wet meadows and marshy areas in valley oak savanna; on poorly drained soils of clays and sandy loam. 15-115 m.							●	●	●	●								●
Delta mudwort *Limosella australis*	RPR 2	riparian scrub, freshwater marsh, brackish marsh. probably the rarest of the suite of delta rare plants. usually on mud banks of the delta in marshy or scrubby riparian associations; often with lilaeopsis masonii. 0-3 m.		●		●	●	●											●	●
Mt. Hamilton lomatium *Lomatium observatorium*	RPR, 1B	cismontane woodland. open to partially shaded openings in pinus coulteri-oak woodland. sedimentary franciscan rocks and volcanics. 1219-1330 m.														●				
Anthony Peak lupine *Lupinus antoninus*	RPR, 1B	upper montane coniferous forest, lower montane coniferous forest. open areas with surrounding forest; rocky sites. 1210-2285 m.								●		●								
Milo Baker's lupine *Lupinus milo-bakeri*	ST, RPR, 1B	cismontane woodland, valley and foothill grassland. in roadside ditches, dry gravelly areas along roads, and along small streams. 360-440 m.								●										
Cobb Mountain lupine *Lupinus sericatus*	RPR, 1B	chaparral, cismontane woodland, lower montane coniferous forest. in stands of knobcone pine-oak woodland, on open wooded slopes in gravelly soils; sometimes on serpentine. 180-1500 m.							●	●	●	●								
Tidestrom's lupine *Lupinus tidestromii*	FE, SE, RPR, 1B	coastal dunes. includes Lupinus tidestromii var. tidestromii, state-listed endangered. partially stabilized dunes, immediately near the ocean. 0-35 m.							●			●		●						
showy golden madia *Madia radiata*	RPR, 1B	valley and foothill grassland, cismontane woodland, chenopod scrub. mostly on adobe clay in grassland or among shrubs. 25-1125 m.		●		●	●	●						●	●	●		●		
Abbott's bush-mallow *Malacothamnus abbottii*	RPR, 1B	riparian scrub. among willows near rivers and along roadsides. 135-525 m.												●						
Indian Valley bush-mallow *Malacothamnus aboriginum*	RPR, 1B	cismontane woodland, chaparral. granitic outcrops and sandy bare soil, often in disturbed soils. 150-1700 m.		●		●								●	●	●	●	●		
arcuate bush-mallow *Malacothamnus arcuatus*	RPR, 1B	chaparral. gravelly alluvium. 80-355 m.		●		●								●	●	●	●	●		
Davidson's bush-mallow *Malacothamnus davidsonii*	RPR, 1B	coastal scrub, riparian woodland, chaparral. sandy washes. 180-855 m.												●		●	●			
Hall's bush-mallow *Malacothamnus hallii*	RPR, 1B	chaparral. some populations on serpentine. 10-550 m.		●		●	●			●		●			●	●	●	●		
Mendocino bush-mallow *Malacothamnus mendocinensis*	RPR, 1B	cismontane woodland. open, roadside banks. label location info inconsistent with elevation info. 420-575 m?								●										
Carmel Valley bush-mallow *Malacothamnus palmeri* var. *involucratus*	RPR, 1B	cismontane woodland, chaparral. talus hilltops and slopes, sometimes on serpentine. burn dependent. 30-1100 m.											●	●		●				

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Arroyo Seco bush-mallow *Malacothamnus palmeri* var. *lucianus*	RPR, 1B	chaparral, meadows and seeps. gravel banks and sandstone rocks on west-facing slopes in full sun. 10-915 m.												●						
Santa Lucia bush-mallow *Malacothamnus palmeri* var. *palmeri*	RPR, 1B	chaparral. dry rocky slopes, mostly near summits, but occasionally extending down canyons to the sea. 60-365 m.												●						
Carmel Valley malacothrix *Malacothrix saxatilis* var. *arachnoidea*	RPR, 1B	chaparral. rock outcrops or steep rocky roadcuts. 25-1215 m.												●						
Oregon meconella *Meconella oregana*	RPR, 1B	coastal prairie, coastal scrub. open, moist places. 250-500 m.		●		●	●								●			●		
northern microseris *Microseris borealis*	RPR 2	bogs and fens, meadows and seeps, lower montane coniferous forest. 940-2000 m.								●										
marsh microseris *Microseris paludosa*	RPR, 1B	closed-cone coniferous forest, cismontane woodland, coastal scrub, valley and foothill grassland. 5-300 m.							●	●		●	●	●		●	●	●		
elongate copper moss *Mielichhoferia elongata*	RPR 2	cismontane woodland. commonly called “copper mosses”. moss growing on very acidic, metamorphic rock or substrate; usually in higher portions in fens. often on substrates natu							●	●		●		●		●		●		
Merced monardella *Monardella leucocephala*	RPR 1A	valley and foothill grassland. known from riverbeds, moist sandy depressions; requires moist subalkaline sands assoc with low elev grassland. 35-100 m.														●				
Palmer’s monardella *Monardella palmeri*	RPR, 1B	cismontane woodland, chaparral. on serpentine, often found associated with sargent cypress forests. 200-800 m.												●						
San Joaquin woollythreads *Monolopia congdonii*	FE, RPR, 1B	chenopod scrub and valley and foothill grassland. alkaline or loamy plains; sandy soils, often with grasses and within chenopod scrub. 60-800 m.										●		●		●				●
woodland woollythreads *Monolopia gracilens*	RPR, 1B	chaparral, valley and foothill grasslands (serpentine), cismontane woodland, broadleafed upland forests, north coast con grassy sites, in openings; sandy to rocky soils. often seen on serpentine after burns but may have only weak affinity to	●	●	●	●	●	●					●	●	●	●	●	●		
Lime Ridge navarretia *Navarretia gowenii*	RPR, 1B	chaparral on calcium carbonate-rich soil with high clay content. 180-305 m		●		●	●									●				
Baker’s navarretia *Navarretia leucocephala* ssp. *bakeri*	RPR, 1B	cismontane woodland, meadows and seeps, vernal pools, valley and foothill grassland, lower montane coniferous forest. vernal pools and swales; adobe or alkaline soils. 5-950 m.							●	●	●	●							●	●
few-flowered navarretia *Navarretia leucocephala* ssp. *pauciflora*	FE, ST, RPR, 1B	vernal pools. volcanic ash flow, and volc substrate vernal pools. 400-855 m.								●	●	●								●
many-flowered navarretia *Navarretia leucocephala* ssp. *plieantha*	FE, SE, RPR, 1B	vernal pools. volcanic ash flow vernal pools. 30-950 m.							●	●		●								
small pincushion navarretia *Navarretia myersii* ssp. *deminuta*	RPR, 1B	vernal pools. known from only one site in lake County in vernal pool habitat on clay-loam soil; also in roadside depressions. 355 m.								●		●								
pincushion navarretia *Navarretia myersii* ssp. *myersii*	RPR, 1B	vernal pools, valley and foothill grassland. clay soils within nonnative grassland. 20-330 m.						●								●				●

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shining navarretia *Navarretia nigelliformis* ssp. *radians*	RPR, 1B	cismontane woodland, valley and foothill grassland, vernal pools. apparently in grassland, and not necessarily in vernal pools. 200-1000 m.	●	●	●	●	●	●						●		●				
prostrate vernal pool navarretia *Navarretia prostrata*	RPR, 1B	coastal scrub, valley and foothill grassland, vernal pools. alkaline soils in grassland, or in vernal pools. mesic, alkaline sites. 15-700 m.	●	●	●	●		●						●	●	●		●		
Marin County navarretia *Navarretia rosulata*	RPR, 1B	closed-cone coniferous forest, chaparral. dry, open rocky places; can occur on serpentine. 200-635 m.							●	●	●	●								●
Robbins' nemacladus *Nemacladus secundiflorus* var. *robbinsii*	RPR, 1B	chaparral, valley and foothill grassland. dry, sandy or gravelly slopes. 350-1700 m.												●		●				
Colusa grass *Neostapfia colusana*	FT, SE, RPR, 1B	vernal pools. usually in large, or deep vernal pool bottoms; adobe soils. 5-110 m.										●				●			●	●
Antioch Dunes evening-primrose *Oenothera deltoides* ssp. *howellii*	FE, SE, RPR, 1B	interior dunes. remnant river bluffs and sand dunes east of Antioch. 0-30 m.		●		●	●	●												●
Wolf's evening-primrose *Oenothera wolfii*	RPR, 1B	coastal bluff scrub, coastal dunes, coastal prairie, lower montane coniferous forest. sandy substrates; usually mesic sites. 3-800 m.								●										
northern adder's-tongue *Ophioglossum pusillum*	RPR 2	marshes and swamps, meadows and seeps. marsh edges, low pastures, grassy roadside ditches. also described as in "open swamp." 1000-2000 m.								●										
San Joaquin Valley Orcutt grass *Orcuttia inaequalis*	FT, SE, RPR, 1B	vernal pools. 30-755 m.										●				●			●	
hairy Orcutt grass *Orcuttia pilosa*	FE, SE, RPR, 1B	vernal pools. 25-125 m.														●				
slender Orcutt grass *Orcuttia tenuis*	FT, SE, RPR, 1B	vernal pools. 30-1735 m.						●		●		●								●
Sacramento Orcutt grass *Orcuttia viscida*	FE, SE, RPR, 1B	vernal pools. 30-100 m.						●												●
Kellman's bristle moss *Orthotrichum kellmanii*	RPR, 1B	chaparral, cismontane oak woodland. sandstone outcrops with high calcium concentrations from eroded boulders out of non-calcareous sandstone bedrock. rock o												●		●	●	●		
seacoast ragwort *Packera bolanderi* var. *bolanderi*	RPR 2	coastal scrub, north coast coniferous forest. 30-650 m.								●										
Geysers panicum *Panicum acuminatum* var. *thermale*	SE, RPR, 1B	closed-cone coniferous forest, riparian forest, valley and foothill grassland. usually around moist, warm soil in the vicinity of hot springs. 305-825 m.							●			●								
Dudley's lousewort *Pedicularis dudleyi*	SR, RPR, 1B	chaparral, north coast coniferous forest, valley and foothill grassland. deep shady woods of older coast redwood forests; also in maritime chaparral. 100-490 m.												●		●	●	●		
Sonoma beardtongue *Penstemon newberryi* var. *sonomensis*	RPR, 1B	chaparral. crevices in rock outcrops and talus slopes. 180-1390 m.							●	●	●	●								●
white-rayed pentachaeta *Pentachaeta bellidiflora*	FE, SE, RPR, 1B	valley and foothill grassland. open dry rocky slopes and grassy areas, often on soils derived from serpentine bedrock. 35-620 m.							●			●		●		●	●	●		

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San Benito pentachaeta *Pentachaeta exilis* ssp. *aeolica*	RPR, 1B	cismontane woodland, valley and foothill grassland. grassy areas. 635-855 m.		●		●								●	●	●		●		
Merced phacelia *Phacelia ciliata* var. *opaca*	RPR, 1B	valley and foothill grassland. adobe or clay soils of valley floors, open hills, or alkaline flats. 60-150 m.														●				
North Coast phacelia *Phacelia insularis* var. *continentis*	RPR, 1B	coastal bluff scrub, coastal dunes. open maritime bluffs, sandy soil. 10-160 m.							●	●		●								
Mt. Diablo phacelia *Phacelia phacelioides*	RPR, 1B	chaparral, cismontane woodland. adjacent to trails, on rock outcrops and talus slopes; sometimes on serpentine. 500-1370 m.		●		●	●							●	●	●		●		
Bolander's beach pine *Pinus contorta* ssp. *bolanderi*	RPR, 1B	closed-cone coniferous forest. podzol-like soils with Mendocino cypress and bishop pine; within pygmy cypress forest. 35-250 m.								●										
Monterey pine *Pinus radiata*	RPR, 1B	closed-cone coniferous forest, cismontane woodland. three primary stands are native to California. dry bluffs and slopes. 25-185 m.											●	●		●	●	●		
white-flowered rein orchid *Piperia candida*	RPR, 1B	north coast coniferous forest, lower montane coniferous forest, broadleafed upland forest. coast ranges from Santa Cruz County north; on serpentine. forest duff, mossy banks, rock outcrops and muskeg. 0-1200 m.		●		●			●	●		●		●	●	●	●	●		
Point Reyes rein orchid *Piperia elegans* ssp. *decurtata*	RPR, 1B	coastal bluff scrub. 15-185 m.							●			●								
Yadon's rein orchid *Piperia yadonii*	FE, RPR, 1B	closed-cone coniferous forest, chaparral, coastal bluff scrub. on sandstone and sandy soil, but poorly drained and often dry. 10-415 m.											●	●						
Choris' popcornflower *Plagiobothrys chorisianus* var. *chorisianus*	RPR, 1B	chaparral, coastal scrub, coastal prairie. mesic sites. 15-100 m.	●		●			●						●		●	●	●		
San Francisco popcornflower *Plagiobothrys diffusus*	SE, RPR, 1B	valley and foothill grassland, coastal prairie. historically from grassy slopes with marine influence. 60-485 m.	●		●			●						●		●	●	●		
hairless popcornflower *Plagiobothrys glaber*	RPR 1A	meadows and seeps, marshes and swamps. coastal salt marshes and alkaline meadows. 5-180 m.	●	●	●	●		●						●	●	●		●		
bearded popcornflower *Plagiobothrys hystriculus*	RPR, 1B	vernal pools, valley and foothill grassland. wet sites. 10-50 m.								●	●	●							●	●
Mayacamas popcornflower *Plagiobothrys lithocaryus*	RPR 1A	meadows? valley and foothill grassland, cismontane woodland, chaparral? moist sites. 285-450 m.								●		●								
Petaluma popcornflower *Plagiobothrys mollis* var. *vestitus*	RPR 1A	valley and foothill grassland, coastal salt marsh? wet sites in grassland, possibly coastal marsh margins. 10-50 m.							●			●								
Calistoga popcornflower *Plagiobothrys strictus*	FE, ST, RPR, 1B	broadleafed upland forest, meadows and seeps, valley and foothill grassland, vernal pools. alkaline sites near thermal springs and on margins of vernal pools in heavy, dark, adobe-like clay. 90-160 m.								●	●									●
hooked popcornflower *Plagiobothrys uncinatus*	RPR, 1B	chaparral, cismontane woodland, valley and foothill grassland, coastal bluff scrub. sandstone outcrops and canyon sides; often in burned or disturbed areas. 300-820 m.												●		●				
warty popcorn-flower *Plagiobothrys verrucosus*	RPR 2	chaparral. shale substrate. 610-760 m.		●		●									●	●		●		

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Species Name	Status	Habitat	AM1	AM2	AV1	AV2	CC1	CC2	MS1	MS2	NC1	NC2	NS1	NS2	SC1	SC2	SM1	SM2	So1	So2
North Coast semaphore grass *Pleuropogon hooverianus*	ST, RPR, 1B	broadleafed upland forest, meadows and seeps, north coast coniferous forest. wet grassy, usually shady areas, sometimes freshwater marsh; associated with forest environments; 10-1150 m.							●	●		●								
Napa blue grass *Poa napensis*	FE, SE, RPR, 1B	meadows and seeps, valley and foothill grassland. moist alkaline meadows fed by runoff from nearby hot springs. 100-125 m.									●									●
Santa Lucia mint *Pogogyne clareana*	SE, RPR, 1B	riparian woodland. tributaries of the Nacimiento River, in moist sandy soil. 300-490 m.																		
Oregon polemonium *Polemonium carneum*	RPR 2	coastal prairie, coastal scrub, lower montane coniferous forest. 0-1830 m.	●		●			●	●			●				●	●	●		
Scotts Valley polygonum *Polygonum hickmanii*	FE, SE, RPR, 1B	valley and foothill grassland. Purisima sandstone or mudstone with a thin soil layer, vernally moist due to runoff. 210-250 m.												●		●		●		
Marin knotweed *Polygonum marinense*	RPR 3	marshes and swamps. coastal salt marshes and brackish marshes. 0-10 m.							●	●	●	●							●	●
Nuttall's ribbon-leaved pondweed *Potamogeton epihydrus*	RPR 2	marshes and swamps. shallow water, ponds, lakes, streams, irrigation ditches. 400-2110 m.								●										
eel-grass pondweed *Potamogeton zosteriformis*	RPR 2	marshes and swamps. ponds, lakes, streams. 0-1860 m.		●		●	●			●		●								
Hickman's cinquefoil *Potentilla hickmanii*	FE, SE, RPR, 1B	coastal bluff scrub, closed-cone coniferous forest, meadows and seeps, marshes and swamps. freshwater marshes, seeps, and small streams in open or forested areas along the coast. 5-125 m.											●	●		●	●			
Cunningham Marsh cinquefoil *Potentilla uliginosa*	RPR 1A	freshwater marshes and swamps. found in permanent, oligotrophic wetlands.30-40 m.							●			●								
Hartweg's golden sunburst *Pseudobahia bahiifolia*	FE, SE, RPR, 1B	valley and foothill grassland, cismontane woodland. clay soils, predominantly on the northern slopes of knolls, but also along shady creeks or near vernal pools. 15-150 m.														●				
dwarf alkali grass *Puccinellia pumila*	RPR 2	meadows and seeps, marshes and swamps. mineral spring meadows and coastal salt marshes. 1-10 m.								●										
Tamalpais oak *Quercus parvula* var. *tamalpaisensis*	RPR, 1B	lower montane coniferous forest. 100-750 m.							●			●								
white beaked-rush *Rhynchospora alba*	RPR 2	bogs and fens, marshes and swamps. freshwater marshes and sphagnum bogs. 60-2000 m.							●	●		●								
California beaked-rush *Rhynchospora californica*	RPR, 1B	bogs and fens, marshes and swamps, lower montane coniferous forest, meadows and seeps. freshwater seeps and open marshy areas. 45-1000 m.							●	●	●	●								●
brownish beaked-rush *Rhynchospora capitellata*	RPR 2	lower montane coniferous forest, meadows and seeps, marshes and swamps, upper montane coniferous forest. mesic sites. 455-2000 m.							●			●								
round-headed beaked-rush *Rhynchospora globularis*	RPR 2	marshes and swamps. freshwater marsh. 45-60 m.							●			●								
pine rose *Rosa pinetorum*	RPR, 1B	closed-cone coniferous forest. 2-300 m.											●	●		●		●		

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Species Name	Status	Habitat	AM1	AM2	AV1	AV2	CC1	CC2	MS1	MS2	NC1	NC2	NS1	NS2	SC1	SC2	SM1	SM2	So1	So2
Sanford's arrowhead *Sagittaria sanfordii*	RPR, 1B	marshes and swamps. in standing or slow-moving freshwater ponds, marshes, and ditches. 0-610 m.		●		●		●				●							●	●
great burnet *Sanguisorba officinalis*	RPR 2	bogs and fens, meadows and seeps, broadleafed upland forest, marshes and swamps, north coast coniferous forest, ripar. forest. rocky serpentine seepage areas and along stream borders. 60-1400 m.								●										
adobe sanicle *Sanicula maritima*	SR, RPR, 1B	meadows and seeps, valley and foothill grassland, chaparral, coastal prairie. moist clay or ultramafic soils. 30-240 m.	●		●			●						●		●		●		
rock sanicle *Sanicula saxatilis*	SR, RPR, 1B	broadleafed upland forest, chaparral, valley and foothill grassland. bedrock outcrops and talus slopes in chaparral or oak woodland habitat. 615-1215 m.		●		●	●								●			●		
marsh skullcap *Scutellaria galericulata*	RPR 2	marshes and swamps, lower montane coniferous forest, meadows and seeps. swamps and wet places. 0-2100 m.		●		●	●	●							●			●		●
side-flowering skullcap *Scutellaria lateriflora*	RPR 2	meadows and seeps, marshes and swamps. wet meadows and marshes. in the delta, often found on logs. -3-500 m.		●		●	●	●												●
Lake County stonecrop *Sedella leiocarpa*	FE, SE, RPR, 1B	valley and foothill grassland, vernal pools, cismontane woodland. level areas that are seasonally wet and dry out in late spring; substrate usually of volcanic origin. 365-790 m.								●		●								
Red Mountain stonecrop *Sedum laxum* ssp. *eastwoodiae*	FC, RPR, 1B	lower montane coniferous forest. serpentine soils among rocks. 600-1200 m.								●										
chaparral ragwort *Senecio aphanactis*	RPR 2	cismontane woodland, coastal scrub. drying alkaline flats. 20-575 m.	●	●	●	●	●	●				●		●		●		●	●	
Point Reyes checkerbloom *Sidalcea calycosa* ssp. *rhizomata*	RPR, 1B	marshes and swamps. freshwater marshes near the coast. 5-75(245)m.							●	●		●								
Hickman's checkerbloom *Sidalcea hickmanii* ssp. *hickmanii*	RPR, 1B	chaparral. grassy openings in chaparral, and on dry ridges. 330-1640 m.												●						
Napa checkerbloom *Sidalcea hickmanii* ssp. *napensis*	RPR, 1B	chaparral. rhyolitic substrates. 415-610 m.							●	●	●	●								●
Lake Pillsbury checkerbloom *Sidalcea hickmanii* ssp. *pillsburiensis*	RPR, 1B	chaparral. openings in chaparral on Franciscan soils. 700 m.								●		●								
Marin checkerbloom *Sidalcea hickmanii* ssp. *viridis*	RPR, 1B	chaparral. serpentine or volcanic soils; sometimes appears after burns. 0-430 m.							●			●								
Keck's checkerbloom *Sidalcea keckii*	FE, RPR, 1B	cismontane woodland, valley and foothill grassland grassy slopes in blue oak woodland. 180-425 m.								●	●	●				●			●	●
Siskiyou checkerbloom *Sidalcea malviflora* ssp. *patula*	RPR, 1B	coastal prairie, broadleafed upland forest. open coastal forest. 15-65 m.								●										
purple-stemmed checkerbloom *Sidalcea malviflora* ssp. *purpurea*	RPR, 1B	broadleafed upland forest, coastal prairie. 15-65 m.							●	●		●								
marsh checkerbloom *Sidalcea oregana* ssp. *hydrophila*	RPR, 1B	meadows and seeps, riparian forest. wet soil of streambanks, meadows. 545-2300 m.							●	●	●	●								●
Kenwood Marsh checkerbloom *Sidalcea oregana* ssp. *valida*	FE, SE, RPR, 1B	marshes and swamps. edges of freshwater marshes. 115-150 m.							●			●								

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Red Mountain catchfly *Silene campanulata* ssp. *campanulata*	SE, RPR 4	lower montane coniferous forest, chaparral. state-listed endangered, but cnps list 4; eo's mostly archived. rocky dry shallow serpentine soil. 420-1200 m. element occurrences archived; cnps list 4.								●										
San Francisco campion *Silene verecunda* ssp. *verecunda*	RPR, 1B	coastal scrub, valley and foothill grassland, coastal bluff scrub, chaparral, coastal prairie. often on mudstone or shale; one site on serpentine. 30-645 m.												●		●	●	●		
prairie wedge grass *Sphenopholis obtusata*	RPR 2	cismontane woodland, meadows and seeps. open moist sites, along rivers and springs, alkaline desert seeps. 360-2325 m.														●				
Santa Cruz microseris *Stebbinsoseris decipiens*	RPR, 1B	broadleafed upland forest, closed-cone coniferous forest, chaparral, coastal prairie, coastal scrub. open areas in loose or disturbed soil, usu. derived from sandstone, shale or serp., on seaward slopes. 10-500 m.							●			●	●	●		●	●	●		
Metcalf Canyon jewel-flower *Streptanthus albidus* ssp. *albidus*	FE, RPR, 1B	valley and foothill grassland. relatively open areas in dry grassy meadows on serpentine soils; also on serpentine balds. 45-245 m.		●		●									●			●		
most beautiful jewel-flower *Streptanthus albidus* ssp. *peramoenus*	RPR, 1B	chaparral, valley and foothill grassland, cismontane woodland. serpentine outcrops, on ridges and slopes. 120-730 m.	●	●	●	●	●	●					●	●	●	●		●		
Tamalpais jewel-flower *Streptanthus batrachopus*	RPR, 1B	closed-cone coniferous forest, chaparral. talus serpentine outcrops. 410-650 m.							●			●								
Socrates Mine jewel-flower *Streptanthus brachiatus* ssp. *brachiatus*	RPR, 1B	chaparral, closed-cone coniferous forest. serpentine areas and serpentine chaparral. 480-970 m.							●	●	●	●								●
Freed's jewel-flower *Streptanthus brachiatus* ssp. *hoffmanii*	RPR, 1B	chaparral, cismontane woodland. serpentine rock outcrops, primarily in geothermal development areas. 480-1030 m.							●	●		●								
Mt. Hamilton jewel-flower *Streptanthus callistus*	RPR, 1B	chaparral, cismontane woodland. open talus slopes on shale with grey pine and/or black oak. 600-790 m.													●			●		
Hoffman's bristly jewel-flower *Streptanthus glandulosus* ssp. *hoffmanii*	RPR, 1B	chaparral, cismontane woodland, valley and foothill grassland. moist, steep rocky banks, in serpentine and non-serpentine soil. 120-475 m.							●			●								
Tiburon jewel-flower *Streptanthus glandulosus* ssp. *niger*	FE, SE, RPR, 1B	valley and foothill grassland. shallow, rocky serpentine slopes. 30-150 m.							●			●								
Mount Tamalpais bristly jewel-flower *Streptanthus glandulosus* ssp. *pulchellus*	RPR, 1B	chaparral, valley and foothill grassland. serpentine slopes. 150-800 m.							●			●								
green jewel-flower *Streptanthus hesperidis*	RPR, 1B	chaparral, cismontane woodland. openings in chaparral or woodland; serpentine, rocky sites. 130-760 m.								●	●	●								●
Mt. Diablo jewel-flower *Streptanthus hispidus*	RPR, 1B	valley and foothill grassland, chaparral. talus or rocky outcrops. 275-970 m.		●		●	●													
Arburua Ranch jewel-flower *Streptanthus insignis* ssp. *lyonii*	RPR, 1B	coastal scrub. serpentine slopes, also on non-serpentine. 230-850 m.														●				

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early jewel-flower *Streptanthus vernalis*	RPR, 1B	chaparral, closed-cone coniferous forest. on serpentine. 610 m.							●	●		●								
slender-leaved pondweed *Stuckenia filiformis*	RPR 2	marshes and swamps. shallow, clear water of lakes and drainage channels. 15-2310 m.	●	●	●	●	●	●				●			●	●	●	●	●	
Mason's neststraw *Stylocline masonii*	RPR, 1B	chenopod scrub, pinyon-juniper woodland. sandy washes. 100-1200 m.												●						
California seablite *Suaeda californica*	FE, RPR, 1B	marshes and swamps. margins of coastal salt marshes. 0-5 m.	●	●	●	●	●	●							●	●		●		
Suisun Marsh aster *Symphyotrichum lentum*	RPR, 1B	marshes and swamps (brackish and freshwater). most often seen along sloughs with phragmites, scirpus, blackberry, typha, etc. 0-3m.		●		●	●	●		●	●	●							●	●
robust false lupine *Thermopsis robusta*	RPR, 1B	north coast coniferous forest, broadleafed upland forest. ridgetops; sometimes on serpentine. 360-1290 m.								●										
alpine crisp moss *Tortella alpicola*	RPR 2	cismontane woodland. moss on volcanic rock (in California). wide ecological tolerance: shaded or exposed, wet or dry, low to high elevations.								●		●								
California screw moss *Tortula californica*	RPR, 1B	chenopod scrub, valley and foothill grassland. moss growing on sandy soil. 10-1460 m.												●						
beaked tracyina *Tracyina rostrata*	RPR, 1B	cismontane woodland, valley and foothill grassland. open grassy meadows within oak woodland and grassland habitats. 150-500 m.							●	●		●								
Wright's trichocoronis *Trichocoronis wrightii* var. *wrightii*	RPR 2	marshes and swamps, riparian forest, meadows and seeps, vernal pools. mud flats of vernal lakes, drying river beds, alkali meadows. 5-435 m.		●		●		●								●				
cylindrical trichodon *Trichodon cylindricus*	RPR 2	broadleafed upland forest, upper montane coniferous forest. moss growing in openings on sandy or clay soils on roadsides, stream banks, trails or in fields. 50-1500 m.								●		●								
Napa bluecurls *Trichostema ruygtii*	RPR, 1B	cismontane woodland, chaparral, valley and foothill grassland, vernal pools, lower montane coniferous forest. often in open, sunny areas. also has been found in vernal pools. 30-590 m.								●	●	●							●	●
showy rancheria clover *Trifolium amoenum*	FE, RPR, 1B	valley and foothill grassland, coastal bluff scrub. sometimes on serpentine soil, open sunny sites, swales. most recently sited on roadside and eroding cliff face. 5-560 m.							●	●	●	●				●	●		●	●
Santa Cruz clover *Trifolium buckwestiorum*	RPR, 1B	coastal prairie, broadleafed upland forest, cismontane woodland. moist grassland. 60-545 m.							●	●		●	●	●		●		●		
saline clover *Trifolium hydrophilum*	RPR, 1B	marshes and swamps, valley and foothill grassland, vernal pools. mesic, alkaline sites. 0-300 m.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Pacific Grove clover *Trifolium polyodon*	SR, RPR, 1B	closed-cone coniferous forest, meadows and seeps, coastal prairie. along small springs and seeps in grassy openings. 5-120 m.											●	●						
Monterey clover *Trifolium trichocalyx*	FE, SE, RPR, 1B	closed-cone coniferous forest. poorly drained, low nutrient soil underlain with hardpan; also openings and burned areas. 120-205 m.								●				●						
San Francisco owl's-clover *Triphysaria floribunda*	RPR, 1B	coastal prairie, valley and foothill grassland. on serpentine and nonserpentine substrate (such as at Pt. Reyes). 10-160 m.							●			●					●	●		

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coastal triquetrella *Triquetrella californica*	RPR, 1B	coastal bluff scrub, coastal scrub valley and foothill grasslands. grows within 30 m from the coast in coastal scrub, grasslands and in open gravels on roadsides, hillsides, rocky slopes,		●		●	●		●	●		●					●	●		●
Cook's triteleia *Triteleia ixioides* ssp. *cookii*	RPR, 1B	cismontane woodland, closed-cone coniferous forest. streamsides, wet ravines; on serpentine and in serpentine seeps. sometimes near cypresses. ?-500 m.												●						
caper-fruited tropidocarpum *Tropidocarpum capparideum*	RPR, 1B	valley and foothill grassland. alkaline clay. 0-455 m.	●	●	●	●	●	●						●		●				
Greene's tuctoria *Tuctoria greenei*	FE, SR, RPR, 1B	vernal pools, valley and foothill grassland. dry bottoms of vernal pools in open grasslands. 30-1065 m.						●								●				
Crampton's tuctoria or Solano grass *Tuctoria mucronata*	FE, SE, RPR, 1B	vernal pools, valley and foothill grassland. clay bottoms of drying vernal pools and lakes in valley grassland. 5-10 m.		●		●						●							●	●
oval-leaved viburnum *Viburnum ellipticum*	RPR 2	chaparral, cismontane woodland, lower montane coniferous forest. 215-1400 m.		●		●	●		●	●	●	●								●
alpine marsh violet *Viola palustris*	RPR 2	coastal scrub, bogs and fens. swampy, shrubby places in coastal scrub or coastal bogs. 0-15 m.								●										

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Invertebrates																				
Lange's metalmark butterfly *Apodemia mormo langei*	FE	inhabits stabilized dunes along the San Joaquin river. endemic to Antioch Dunes, Contra Costa County. primary host plant is *Eriogonum nudum var auriculatum*; feeds on nectar of other wildflowers, as well as host plant.		●		●	●													
Conservancy fairy shrimp *Branchinecta conservatio*	FE	endemic to the grasslands of the northern two-thirds of the Central Valley; found in large, turbid pools. inhabit astatic pools located in swales formed by old, braided alluvium; filled by winter/spring rains, last until June.										●				●			●	●
longhorn fairy shrimp *Branchinecta longiantenna*	FE	endemic to the eastern margin of the central coast mountains in seasonally astatic grassland vernal pools. inhabit small, clear-water depressions in sandstone and clear-to-turbid clay/grass-bottomed pools in shallow swales.	●	●	●	●	●	●								●				
vernal pool fairy shrimp *Branchinecta lynchi*	FT	endemic to the grasslands of the Central Valley, central coast mountains, and south coast mountains, in astatic rain-filled pools. inhabit small, clear-water sandstone-depression pools and grassed swale, earth slump, or basalt-flow depression pools.	●	●	●	●	●	●		●	●	●		●		●			●	●
San Bruno elfin butterfly *Callophrys mossii bayensis*	FE	coastal, mountainous areas with grassy ground cover, mainly in the vicinity of San Bruno Mountain, San Mateo County. colonies are located on steep, north-facing slopes within the fog belt. larval host plant is *Sedum spathulifolium*.		●		●	●		●			●				●	●			
Ohlone tiger beetle *Cicindela ohlone*	FE	remnant native grasslands with California oatgrass and purple needlegrass in Santa Cruz County. substrate is poorly-drained clay or sandy clay soil over bedrock of Santa Cruz mudstone.											●			●		●		
valley elderberry longhorn beetle *Desmocerus californicus dimorphus*	FT	occurs only in the Central Valley of California, in association with blue elderberry (Sambucus mexicana). prefers to lay eggs in elderberrries 2-8 inches in diameter; some preference shown for "stressed" elderberries.		●		●		●		●	●	●				●			●	●
Delta green ground beetle *Elaphrus viridis*	FT	restricted to the margins of vernal pools in the grassland area between Jepson Prairie and Travis AFB. prefers the sandy mud substrate where it slopes gently into the water, with low-growing vegetation, 25-100% cover.										●							●	
Smith's blue butterfly *Euphilotes enoptes smithi*	FE	most commonly associated with coastal dunes and coastal sage scrub plant communities in Monterey and Santa Cruz Counties. hostplant: *Eriogonum latifolium* and *Eriogonum* parvifolium are utilized as both larval and adult foodplants.											●	●		●		●		
Bay checkerspot butterfly *Euphydryas editha bayensis*	FT	restricted to native grasslands on outcrops of serpentine soil in the vicinity of San Francisco Bay. *Plantago erecta* is the primary host plant; *Orthocarpus densiflorus* and *O. purpurscens* are the secondary host plants.	●	●	●	●	●	●						●	●	●	●	●		
vernal pool tadpole shrimp *Lepidurus packardi*	FE	inhabits vernal pools and swales in the Sacramento valley containing clear to highly turbid water. pools commonly found in grass bottomed swales of unplowed grasslands. some pools are mud-bottomed and highly turbid.	●	●	●	●	●	●				●				●			●	●
Mission blue butterfly *Plebejus icarioides missionensis*	FE	inhabits grasslands of the San Francisco peninsula. three larval host plants: *Lupinus albifrons, L. variicolor*, and *L. formosus*, of which *L. albifrons* is favored.							●			●				●	●	●		

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lotis blue butterfly *Plebejus idas lotis*	FE	inhabits wet meadows or poorly-drained sphagnum-willow bogs, where soils are waterlogged and acidic; north coastal California. inhabits upper edges of peat bog between peat and surrounding low willows; hostplant is *Lotus formosissimus*.								●										
Mount Hermon (=barbate) June beetle *Polyphylla barbata*	FE	known only from sand hills in vicinity of Mt. Hermon, Santa Cruz County.												●		●		●		
callippe silverspot butterfly *Speyeria callippe callippe*	FE	restricted to the northern coastal scrub of the San Francisco peninsula. hostplant is *Viola pedunculata*. most adults found on e-facing slopes; males congregate on hilltops in search of females.														●	●	●		
Behren's silverspot butterfly *Speyeria zerene behrensii*	FE	restricted to the pacific side of the coast ranges, from point arena to Cape Mendocino, Mendocino County inhabits coastal terrace prairie habitat. foodplant is *Viola* sp.							●	●		●								
Myrtle's silverspot *Speyeria zerene myrtleae*	FE	restricted to the foggy, coastal dunes/hills of the point reyes peninsula; extirpated from coastal San Mateo County. larval foodplant thought to be *Viola adunca*.							●			●				●	●			
California freshwater shrimp *Syncaris pacifica*	FE, SE,	endemic to Marin, Napa, and Sonoma Counties. found in low elevation, low gradient streams where riparian cover is moderately shallow pools away from main streamflow. winter: undercut banks with exposed roots. summer: leafy branches touching water.							●	●	●	●								●
Zayante band-winged grasshopper *Trimerotropis infantilis*	FE	isolated sandstone deposits in the Santa Cruz Mountains (the Zayante Sand Hills ecosystem) mostly on sand parkland habitat but also in areas with well-developed ground cover and in sparse chaparral with grass.		●		●								●	●	●		●		
Fish																				
Sacramento perch *Archoplites interruptus*	SSC	historically found in the sloughs, slow-moving rivers, and lakes of the Central Valley. prefers warm water. aquatic vegetation is essential for young. tolerates wide range of physio-chemical water conditions.		●		●	●													●
Kern brook lamprey *Entosphenus hubbsi*	SSC	San Joaquin river system and kern river. gravel-bottomed areas for spawning and muddy-bottomed areas where ammocoetes can burrow and feed.														●				
tidewater goby *Eucyclogobius newberryi*	FE, SSC	brackish water habitats along the California coast from Agua Hedionda Lagoon, San Diego County to the mouth of the smith river. found in shallow lagoons and lower stream reaches, they need fairly still but not stagnant water and high oxygen levels.	●		●			●	●	●		●	●	●		●	●	●		
Delta smelt *Hypomesus transpacificus*	FT, SE	Sacramento-San Joaquin Delta. seasonally in Suisun Bay, Carquinez Strait and San Pablo Bay. seldom found at salinities > 10 ppt. most often at salinities < 2ppt.		●		●		●				●							●	●
Russian River tule perch *Hysterocarpus traski pomo*	SSC	low elevation streams of the Russian River system. requires clear, flowing water with abundant cover. they also require deep (> 1 m) pool habitat.							●			●								
Clear Lake hitch *Lavinia exilicauda chi*	SSC	found only in Clear Lake, Lake County, and associated ponds. spawns in streams flowing into clear lake. adults found in the limnetic zone. juveniles found in the nearshore shallow-water habitat hiding in the vegetation.								●		●								
Navarro roach *Lavinia symmetricus navarroensis*	SSC	habitat generalists. found in warm intermittent streams as well as cold, well-aerated streams.							●	●		●								

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Gualala roach *Lavinia symmetricus parvipinnis*	SSC	found only in the Gualala River.							●	●		●								
San Joaquin roach *Lavinia symmetricus* ssp. 1	SSC	tributaries to the San Joaquin river from the Cosumnes River south.														●				
Tomales roach *Lavinia symmetricus* ssp. 2	SSC	tributaries to Tomales Bay.							●			●								
hardhead *Mylopharodon conocephalus*	SSC	low to mid-elevation streams in the Sacramento-San Joaquin drainage. also present in the Russian River. clear, deep pools with sand-gravel-boulder bottoms and slow water velocity. not found where exotic centrarchids predominate.		●		●		●	●			●				●	●	●		
pink salmon *Oncorhynchus gorbuscha*	SSC	most spawn in intertidal or lower reaches of streams and rivers in September and October move further upstream in Sacramento river. optimal temperature is 5.6 to 14.4°C. embryos and alevins require fast-flowing, well oxygenated water for development and survival.								●										
Coho salmon - central California coast ESU *Oncorhynchus kisutch*	FE, SE	federal listing = populations between Punta Gorda and San Lorenzo River. state listing = populations south of Punta Gorda. require beds of loose, silt-free, coarse gravel for spawning. also need cover, cool water and sufficient dissolved oxygen.							●	●		●		●		●		●		
Coho salmon - southern Oregon / northern California ESU *Oncorhynchus kisutch*	FT, ST, SSC	federal listing refers to populations between Cape Blanco, Oregon and Punta Gorda, Humboldt County, California. state listing refers to populations between the Oregon border and Punta Gorda, California.																		
summer-run steelhead trout *Oncorhynchus mykiss irideus*	SSC	northern California coastal streams south to Middle Fork Eel River. within range of Klamath Mountains Province DPS and northern California DPS. cool, swift, shallow water and clean loose gravel for spawning, and suitably large pools in which to spend the summer.								●										
steelhead - central California coast DPS *Oncorhynchus mykiss irideus*	FT	from Russian River, south to Soquel Creek and to, but not including, Pajaro River. also San Francisco and San Pablo Bay basins.							●	●	●	●		●		●	●	●		●
steelhead - northern California DPS *Oncorhynchus mykiss irideus*	FT, SSC	coastal basins from redwood creek south to the Gualala River, inclusive. does not include summer-run steelhead.								●										
steelhead - south/central California coast DPS *Oncorhynchus mykiss irideus*	FT, SSC	fed listing refers to runs in coastal basins from the Pajaro River south to, but not including, the Santa Maria River.		●		●								●	●	●		●		
Chinook salmon - Sacramento River winter-run ESU *Oncorhynchus tshawytscha*	FE, SE	Sacramento river below Keswick Dam. spawns in the Sacramento river but not in tributary streams. requires clean, cold water over gravel beds with water temperatures between 6 and 14 c for spawning.										●								●
Chinook salmon - Central Valley spring-run ESU *Oncorhynchus tshawytscha*	FT, ST	adult numbers depend on pool depth and volume, amount of cover, and proximity to gravel. water temps >27 c is lethal to adults federal listing refers to pops spawning in Sacramento river and tributaries.										●								●
Sacramento splittail *Pogonichthys macrolepidotus*	SSC	endemic to the lakes and rivers of the Central Valley, but now confined to the delta, Suisun Bay and associated marshes. slow moving river sections, dead end sloughs. requires flooded vegetation for spawning and foraging for young.		●		●		●	●			●				●			●	●

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longfin smelt *Spirinchus thaleichthys*	ST, SSC	euryhaline, nektonic and anadromous. found in open waters of estuaries, mostly in middle or bottom of water column. prefer salinities of 15-30 ppt, but can be found in completely freshwater to almost pure seawater.							●			●								
Amphibians																				
California tiger salamander *Ambystoma californiense*	FT, ST, SSC	Central Valley DPS federally listed as threatened. Santa Barbara and Sonoma Counties DPS federally listed as endangered. need underground refuges, especially ground squirrel burrows and vernal pools or other seasonal water sources for breeding	●	●	●	●		●	●			●	●	●	●	●	●	●	●	●
Santa Cruz long-toed salamander *Ambystoma macrodactylum croceum*	FE, SE,	wet meadows near sea level in a few restricted locales in Santa Cruz and Monterey Counties. aquatic larvae prefer shallow (<12 inches) water, using clumps of vegetation or debris for cover. adults use mammal burr											●	●		●		●		
arroyo toad *Anaxyrus californicus*	FE, SSC	semi-arid regions near washes or intermittent streams, including valley-foothill and desert riparian, desert wash, etc. rivers with sandy banks, willows, cottonwoods, and sycamores; loose, gravelly areas of streams in drier parts of range.												●						
Pacific tailed frog *Ascaphus truei*	SSC	occurs in montane hardwood-conifer, redwood, Douglas-fir and ponderosa pine habitats. restricted to perennial montane streams. tadpoles require water below 15 degrees C.																		
northern leopard frog *Lithobates pipiens*	SSC	native range is east of Sierra Nevada-Cascade crest. near permanent or semi-permanent water in a variety of habitats. highly aquatic species. shoreline cover, submerged and emergent aquatic vegetation are important habitat characteristics														●				
northern red-legged frog *Rana aurora*	SSC	humid forests, woodlands, grasslands, and streamsides in northwestern California, usually near dense riparian cover. generally near permanent water, but can be found far from water, in damp woods and meadows, during non-breeding season.								●										
foothill yellow-legged frog *Rana boylii*	SSC	partly-shaded, shallow streams and riffles with a rocky substrate in a variety of habitats. need at least some cobble-sized substrate for egg-laying. need at least 15 weeks to attain metamorphosis.	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●
California red-legged frog *Rana draytonii*	FT, SSC	lowlands and foothills in or near permanent sources of deep water with dense, shrubby or emergent riparian vegetation. requires 11-20 weeks of permanent water for larval development. must have access to estivation habitat.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
southern torrent salamander *Rhyacotriton variegatus*	SSC	coastal redwood, Douglas-fir, mixed conifer, montane riparian, and montane hardwood-conifer habitats. old growth forest. cold, well-shaded, permanent streams and seepages, or within splash zone or on moss-covered rock within trickling water.								●										
western spadefoot *Spea hammondii*	SSC	occurs primarily in grassland habitats, but can be found in valley-foothill hardwood woodlands. vernal pools are essential for breeding and egg-laying.	●	●	●	●		●				●		●		●				●
Coast Range newt *Taricha torosa*	SSC	coastal drainages from Mendocino County to San Diego County. lives in terrestrial habitats and will migrate over 1 km to breed in ponds, reservoirs and slow moving streams.											●	●		●				

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Reptiles																				
black legless lizard *Anniella pulchra nigra*	SSC	sand dunes and sandy soils in the Monterey Bay and Morro Bay regions. inhabit sandy soil/dune areas with bush lupine and mock heather as dominant plants. moist soil is essential.											●	●		●		●		
silvery legless lizard *Anniella pulchra pulchra*	SSC	sandy or loose loamy soils under sparse vegetation. soil moisture is essential. they prefer soils with a high moisture content.		●		●	●	●					●	●		●				
western pond turtle *Emys marmorata*	SSC	a thoroughly aquatic turtle of ponds, marshes, rivers, streams and irrigation ditches, usually with aquatic vegetation, be need basking sites and suitable (sandy banks or grassy open fields) upland habitat up to 0.5 km from water for egg-laying.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
blunt-nosed leopard lizard *Gambelia sila*	FE, SE	resident of sparsely vegetated alkali and desert scrub habitats, in areas of low topographic relief. seeks cover in mammal burrows, under shrubs or structures such as fence posts; they do not excavate their own burrows.												●		●				
San Joaquin whipsnake *Masticophis flagellum ruddocki*	SSC	open, dry habitats with little or no tree cover. found in valley grassland and saltbush scrub in the San Joaquin Valley. needs mammal burrows for refuge and oviposition sites.	●	●	●	●	●	●						●		●				
Alameda whipsnake *Masticophis lateralis euryxanthus*	FT, ST	typically found in chaparral and scrub habitats but will also use adjacent grassland, oak savanna and woodland habitats. mostly south-facing slopes and ravines, with rock outcrops, deep crevices or abundant rodent burrows, where shrubs form a	●	●	●	●	●	●							●	●		●		
coast horned lizard *Phrynosoma blainvillii*	SSC	frequents a wide variety of habitats, most common in lowlands along sandy washes with scattered low bushes. open areas for sunning, bushes for cover, patches of loose soil for burial, and abundant supply of ants and other insects.	●	●	●	●	●	●					●	●	●	●		●		
giant garter snake *Thamnophis gigas*	FT, ST	prefers freshwater marsh and low gradient streams. has adapted to drainage canals and irrigation ditches. this is the most aquatic of the garter snakes in California.		●		●		●				●				●			●	●
two-striped garter snake *Thamnophis hammondii*	SSC	coastal California from vicinity of Salinas to northwest Baja California. from sea to about 7,000 ft elevation. highly aquatic, found in or near permanent fresh water. often along streams with rocky beds and riparian growth.												●		●				
San Francisco garter snake *Thamnophis sirtalis tetrataenia*	FE, SE	vicinity of freshwater marshes, ponds and slow moving streams in San Mateo County and extreme northern Santa Cruz County. prefers dense cover and water depths of at least one foot. upland areas near water are also very important.												●		●	●	●		
Birds																				
northern goshawk *Accipiter gentilis*	SSC	within, and in vicinity of, coniferous forest. uses old nests, and maintains alternate sites. usually nests on north slopes, near water. red fir, lodgepole pine, Jeffrey pine, and aspens are typical nest trees.								●		●								
tricolored blackbird *Agelaius tricolor*	SSC	highly colonial species, most numerous in Central Valley and vicinity. largely endemic to California. requires open water, protected nesting substrate, and foraging area with insect prey within a few km of the colony.	●	●	●	●		●	●	●	●	●	●	●	●	●		●	●	●
grasshopper sparrow *Ammodramus savannarum*	SSC	dense grasslands on rolling hills, lowland plains, in valleys and on hillsides on lower mountain slopes. favors native grasslands with a mix of grasses, forbs and scattered shrubs. loosely colonial when nesting.							●	●		●							●	

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golden eagle *Aquila chrysaetos*	FP	rolling foothills, mountain areas, sage-juniper flats, and desert. cliff-walled canyons provide nesting habitat in most parts of range; also, large trees in open areas.	●	●	●	●	●	●		●	●	●	●	●	●	●		●	●	●
short-eared owl *Asio flammeus*	SSC	found in swamp lands, both fresh and salt; lowland meadows; irrigated alfalfa fields. tule patches/tall grass needed for nesting/daytime seclusion. nests on dry ground in depression concealed in vegetation.		●		●	●					●	●	●		●	●		●	
long-eared owl *Asio otus*	SSC	riparian bottomlands grown to tall willows and cottonwoods; also, belts of live oak paralleling stream courses. require adjacent open land productive of mice and the presence of old nests of crows, hawks, or magpies for breeding.												●		●	●			
burrowing owl *Athene cunicularia*	SSC	open, dry annual or perennial grasslands, deserts and scrublands characterized by low-growing vegetation. subterranean nester, dependent upon burrowing mammals, most notably, the California ground squirrel.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
marbled murrelet *Brachyramphus marmoratus*	FT, SE	feeds near-shore; nests inland along coast from Eureka to Oregon border and from half moon bay to Santa Cruz. nests in old-growth redwood-dominated forests, up to six miles inland, often in Douglas-fir.												●		●		●		
Swainson's hawk *Buteo swainsoni*	SSC	breeds in grasslands with scattered trees, juniper-sage flats, riparian areas, savannahs, and agricultural or ranch lands requires adjacent suitable foraging areas such as grasslands, or alfalfa or grain fields supporting rodent populations.	●	●	●	●	●	●		●	●	●				●			●	●
western snowy plover *Charadrius alexandrinus nivosus*	FT, SSC	sandy beaches, salt pond levees and shores of large alkali lakes. needs sandy, gravelly or friable soils for nesting.	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●		●
mountain plover *Charadrius montanus*	SSC	short grasslands, freshly plowed fields, newly sprouting grain fields, and sometimes sod farms short vegetation, bare ground and flat topography. prefers grazed areas and areas with burrowing rodents.										●		●		●			●	●
northern harrier *Circus cyaneus*	SSC	coastal salt and fresh-water marsh. nest and forage in grasslands, from salt grass in desert sink to mountain cienagas. nests on ground in shrubby vegetation, usually at marsh edge; nest built of a large mound of sticks in wet areas.	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●
western yellow-billed cuckoo *Coccyzus americanus occidentalis*	FC, SE	riparian forest nester, along the broad, lower flood-bottoms of larger river systems. nests in riparian jungles of willow, often mixed with cottonwoods, with lower story of blackberry, nettles, or wild grape.		●		●		●	●	●		●		●		●				●
yellow rail *Coturnicops noveboracensis*	SSC	summer resident in eastern Sierra Nevada in Mono County. fresh-water marshlands.														●				
black swift *Cypseloides niger*	SSC	coastal belt of Santa Cruz and Monterey County; central and southern Sierra Nevada; San Bernardino and San Jacinto Mountains. breeds in small colonies on cliffs behind or adjacent to waterfalls in deep canyons and sea-bluffs above the surf; foraging		●		●			●	●	●	●		●	●	●	●	●		●
yellow warbler *Dendroica petechia brewsteri*	SSC	riparian plant associations. prefers willows, cottonwoods, aspens, sycamores, and alders for nesting and foraging. also nests in montane shrubbery in open conifer forests.	●	●	●	●		●	●	●		●		●		●				
white-tailed kite *Elanus leucurus*	FP	rolling foothills and valley margins with scattered oaks and river bottomlands or marshes next to deciduous woodland. open grasslands, meadows, or marshes for foraging close to isolated, dense-topped trees for nesting and perching.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

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American peregrine falcon *Falco peregrinus anatum*	SSC	near wetlands, lakes, rivers, or other water; on cliffs, banks, dunes, mounds; also, human-made structures. nest consists of a scrape or a depression or ledge in an open site.	●	●	●	●		●		●	●	●		●	●	●	●	●	●	●
tufted puffin *Fratercula cirrhata*	SSC	open-ocean bird; nests along the coast on islands, islets, or (rarely) mainland cliffs. requires sod or earth into which the birds can burrow, on island cliffs or grassy island slopes.							●	●		●		●						
saltmarsh common yellowthroat *Geothlypis trichas sinuosa*	SSC	resident of the San Francisco Bay region, in fresh and salt water marshes. requires thick, continuous cover down to water surface for foraging; tall grasses, tule patches, willows for nesting.	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●
California condor *Gymnogyps californianus*	FE, SE	require vast expanses of open savannah, grasslands, and foothill chaparral in mountain ranges of moderate altitude. deep canyons containing clefts in the rocky walls provide nesting sites. forages up to 100 miles from roost/nest.												●		●				
bald eagle *Haliaeetus leucocephalus*	SE	ocean shore, lake margins, and rivers for both nesting and wintering. most nests within 1 mile of water. nests in large, old-growth, or dominant live tree with open branches, especially ponderosa pine. roosts communally in winte	●	●	●	●	●	●		●	●	●		●		●				●
yellow-breasted chat *Icteria virens*	SSC	summer resident; inhabits riparian thickets of willow and other brushy tangles near watercourses. nests in low, dense riparian, consisting of willow, blackberry, wild grape; forages and nests within 10 ft of ground.	●	●	●	●		●		●		●		●		●			●	
loggerhead shrike *Lanius ludovicianus*	SSC	broken woodlands, savannah, pinyon-juniper, Joshua tree, and riparian woodlands, desert oases, scrub and washes. prefers open country for hunting, with perches for scanning, and fairly dense shrubs and brush for nesting.		●		●	●	●	●			●				●				
California black rail *Laterallus jamaicensis coturniculus*	ST	inhabits freshwater marshes, wet meadows and shallow margins of saltwater marshes bordering larger bays. needs water depths of about 1 inch that does not fluctuate during the year and dense vegetation for nesting habitat.	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●
Suisun song sparrow *Melospiza melodia maxillaris*	SSC	resident of brackish-water marshes surrounding Suisun Bay. inhabits cattails, tules and other sedges, and salicornia; also known to frequent tangles bordering sloughs.		●		●	●	●				●				●			●	●
Alameda song sparrow *Melospiza melodia pusillula*	SSC	resident of salt marshes bordering south arm of San Francisco Bay. inhabits salicornia marshes; nests low in grindelia bushes (high enough to escape high tides) and in salicornia.	●	●	●	●	●	●							●	●	●	●		
San Pablo song sparrow *Melospiza melodia samuelis*	SSC	resident of salt marshes along the north side of San Francisco and San Pablo Bays. inhabits tidal sloughs in the salicornia marshes; nests in grindelia bordering slough channels.		●		●	●		●	●	●	●							●	●
ashy storm-petrel *Oceanodroma homochroa*	SSC	colonial nester on off-shore islands. usually nests on driest part of islands. forages over open ocean. nest sites on islands are in crevices beneath loosely piled rocks or driftwood, or in caves.							●	●		●						●		
California brown pelican *Pelecanus occidentalis californicus*	SSC, FP	colonial nester on coastal islands just outside the surf line. nests on coastal islands of small to moderate size which afford immunity from attack by ground-dwelling predators. roost												●						
purple martin *Progne subis*	SSC	inhabits woodlands, low elevation coniferous forest of Douglas-fir, ponderosa pine, and Monterey pine. nests in old woodpecker cavities mostly, also in human-made structures. nest often located in tall, isolated tree/snag.						●		●	●	●		●						●

FC = federal candidate species
FE = federally listed as endangered
FP = California Fully Protected species
FT = federally listed as threatened
SE = listed by California as endangered
SSC = California species of concern
ST = listed by California as threatened

Table A-2 CNDDB Occurrences for Special-status Wildlife Species by District and Adjacent Program Areas

Species Name	Status	Habitat	AM1	AM2	AV1	AV2	CC1	CC2	MS1	MS2	NC1	NC2	NS1	NS2	SC1	SC2	SM1	SM2	So1	So2
California clapper rail *Rallus longirostris obsoletus*	FE, SE	salt-water and brackish marshes traversed by tidal sloughs in the vicinity of San Francisco Bay. associated with abundant growths of pickleweed, but feeds away from cover on invertebrates from mud-bottomed sloughs.	●	●	●	●	●	●	●		●	●	●	●	●	●	●	●	●	●
bank swallow *Riparia riparia*	ST	colonial nester; nests primarily in riparian and other lowland habitats west of the desert. requires vertical banks/cliffs with fine-textured/sandy soils near streams, rivers, lakes, ocean to dig nesting hole.	●	●	●	●		●	●	●	●	●	●	●	●	●	●	●		●
black skimmer *Rynchops niger*	SSC	nests on gravel bars, low islets, and sandy beaches, in unvegetated sites. nesting colonies usually less than 200 pairs.	●		●			●								●				
California least tern *Sternula antillarum browni*	FE, SE	nests along the coast from San Francisco Bay south to northern Baja California. colonial breeder on bare or sparsely vegetated, flat substrates: sand beaches, alkali flats, landfills, or paved areas.	●	●	●	●	●	●				●			●	●	●	●	●	
least Bell's vireo *Vireo bellii pusillus*	FE, SE	summer resident of southern California in low riparian in vicinity of water or in dry river bottoms; below 2000 ft. nests placed along margins of bushes or on twigs projecting into pathways, usually willow, baccharis, mesquite.		●		●						●		●	●	●		●		●
yellow-headed blackbird *Xanthocephalus xanthocephalus*	SSC	nests in freshwater emergent wetlands with dense vegetation and deep water. often along borders of lakes or ponds. nests only where large insects such as odonata are abundant, nesting timed with maximum emergence of aquatic insects.		●		●	●	●				●				●				●
Mammals																				
Nelson's antelope squirrel *Ammospermophilus nelsoni*	ST	western San Joaquin valley from 200-1200 ft elev. on dry, sparsely vegetated loam soils. dig burrows or use k-rat burrows. need widely scattered shrubs, forbs and grasses in broken terrain with gullies and washes												●		●				
pallid bat *Antrozous pallidus*	SSC	deserts, grasslands, shrublands, woodlands and forests. most common in open, dry habitats with rocky areas for roosting. roosts must protect bats from high temperatures. very sensitive to disturbance of roosting sites.	●	●	●	●	●	●	●	●	●	●		●	●	●	●	●	●	●
Point Arena mountain beaver *Aplodontia rufa nigra*	FE, SSC	coastal areas of point arena with springs or seepages. north-facing slopes of ridges and gullies with friable soils and thickets of undergrowth.								●										
Point Reyes mountain beaver *Aplodontia rufa phaea*	SSC	coastal area of Point Reyes in areas of springs or seepages. north-facing slopes of hills and gullies in areas overgrown with sword ferns and thimbleberries.							●			●								
Sonoma tree vole *Arborimus pomo*	SSC	north coast fog belt from Oregon border to Sonoma County in Douglas-fir, redwood and montane hardwood-conifer forests. feeds almost exclusively on Douglas-fir needles. will occasionally take needles of grand fir, hemlock or spruce.							●	●		●								
Guadalupe fur-seal *Arctocephalus townsendi*	FT, ST	breeds on Isla De Guadalupe off of Mexico, occasionally found on San Miguel, San Nicolas, and San Clemente Islands. prefers shallow, nearshore island water, with cool and sheltered rocky areas for haul-outs.																●		
Townsend's big-eared bat *Corynorhinus townsendii*	SSC	throughout California in a wide variety of habitats. most common in mesic sites. roosts in the open, hanging from walls and ceilings. roosting sites limiting. extremely sensitive to human disturbance.	●		●			●	●	●	●	●		●		●		●		●

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Table A-2 CNDDB Occurrences for Special-status Wildlife Species by District and Adjacent Program Areas

Species Name	Status	Habitat	AM1	AM2	AV1	AV2	CC1	CC2	MS1	MS2	NC1	NC2	NS1	NS2	SC1	SC2	SM1	SM2	So1	So2
giant kangaroo rat *Dipodomys ingens*	FE, SE,	annual grasslands on the western side of the San Joaquin valley, marginal habitat in alkali scrub. need level terrain and sandy loam soils for burrowing.												●		●				
big-eared kangaroo rat *Dipodomys venustus elephantinus*	SSC	chaparral-covered slopes of the southern part of the Gabilian Range, in the vicinity of the Pinnacles. forages under shrubs and in the open. burrows for cover and for nesting.												●						
southern sea otter *Enhydra lutris nereis*	FT	nearshore marine environments from about Ano Nuevo, San Mateo County to Point Sal, Santa Barbara County needs canopies of giant kelp and bull kelp for rafting and feeding. prefers rocky substrates with abundant invertebrates.							●			●								
Steller (=northern) sea-lion *Eumetopias jubatus*	FT	breeds on Ano Nuevo, San Miguel and Farallon Islands, pt. St. George, and Sugarloaf. hauls-out on islands and rocks. needs haul-out and breeding sites with unrestricted access to water, near aquatic food supply and with no human disturbance.																●		
western mastiff bat *Eumops perotis californicus*	SSC	many open, semi-arid to arid habitats, including conifer and deciduous woodlands, coastal scrub, grasslands, chaparral etc. roosts in crevices in cliff faces, high buildings, trees and tunnels.	●	●	●	●		●						●		●				
California wolverine *Gulo gulo*	FC, ST	found in the north coast mountains and the Sierra Nevada. found in a wide variety of high elevation habitats. needs water source. uses caves, logs, burrows for cover and den area. hunts in more open areas. can travel long distances								●										
western red bat *Lasiurus blossevillii*	SSC	roosts primarily in trees, 2-40 ft above ground, from sea level up through mixed conifer forests. prefers habitat edges and mosaics with trees that are protected from above and open below with open areas for foraging.		●		●	●	●	●	●	●	●		●		●			●	●
Humboldt marten *Martes americana humboldtensis*	SSC	occurs only in the coastal redwood zone from the Oregon border south to Sonoma County. associated with late-successional coniferous forests, prefer forests with low, overhead cover.								●		●								
Pacific fisher *Martes pennanti* (*pacifica*) DPS	FC, SSC	intermediate to large-tree stages of coniferous forests and deciduous-riparian areas with high percent canopy closure. uses cavities, snags, logs and rocky areas for cover and denning. needs large areas of mature, dense forest.								●		●								
San Pablo vole *Microtus californicus sanpabloensis*	SSC	saltmarshes of San Pablo Creek, on the south shore of San Pablo Bay. constructs burrow in soft soil. feeds on grasses, sedges and herbs. forms a network of runways leading from the burrow																		
San Francisco dusky-footed woodrat *Neotoma fuscipes annectens*	SSC	forest habitats of moderate canopy and moderate to dense understory. may prefer chaparral and redwood habitats. constructs nests of shredded grass, leaves and other material. may be limited by availability of nest-building materials.	●	●	●	●	●	●						●	●	●		●		
riparian (=San Joaquin Valley) woodrat *Neotoma fuscipes riparia*	FE, SSC	riparian areas along the San Joaquin, Stanislaus and Tuolumne Rivers. need areas with mix of brush and trees. need suitable nesting sites in trees, snags or logs.						●								●				
Monterey dusky-footed woodrat *Neotoma macrotis luciana*	SSC	forest habitats of moderate canopy and moderate to dense understory. also in chaparral habitats. nests constructed of grass, leaves, sticks, feathers, etc. population may be limited by availability of nest materials												●		●				
big free-tailed bat *Nyctinomops macrotis*	SSC	low-lying arid areas in southern California. need high cliffs or rocky outcrops for roosting sites. feeds principally on large moths.	●	●	●	●	●	●								●	●			

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Table A-2 CNDDB Occurrences for Special-status Wildlife Species by District and Adjacent Program Areas

Species Name	Status	Habitat	AM1	AM2	AV1	AV2	CC1	CC2	MS1	MS2	NC1	NC2	NS1	NS2	SC1	SC2	SM1	SM2	So1	So2
Tulare grasshopper mouse *Onychomys torridus tularensis*	SSC	hot, arid valleys and scrub deserts in the southern San Joaquin valley. diet almost exclusively composed of arthropods, therefore needs abundant supply of insects.												●		●				
Salinas pocket mouse *Perognathus inornatus psammophilus*	SSC	annual grassland and desert shrub communities in the Salinas Valley. fine-textured, sandy, friable soils. burrows for cover and nesting.																		
salt-marsh harvest mouse *Reithrodontomys raviventris*	FE, SE	only in the saline emergent wetlands of San Francisco Bay and its tributaries. pickleweed is primary habitat. do not burrow, build loosely organized nests. require higher areas for flood escape.	●	●	●	●	●	●	●	●	●	●			●	●	●	●	●	●
Alameda Island mole *Scapanus latimanus parvus*	SSC	only known from Alameda island. found in a variety of habitats, especially annual and perennial grasslands. prefers moist, friable soils. avoids flooded soils.	●		●			●								●				
Suisun shrew *Sorex ornatus sinuosus*	SSC	tidal marshes of the northern shores of San Pablo and Suisun Bays. require dense low-lying cover and driftweed and other litter above the mean high tide line for nesting and foraging.																	●	
salt-marsh wandering shrew *Sorex vagrans halicoetes*	SSC	salt marshes of the south arm of San Francisco Bay. medium high marsh 6-8 ft above sea level where abundant driftwood is scattered among salicornia.	●	●	●	●	●	●	●	●	●	●			●	●	●	●		●
riparian brush rabbit *Sylvilagus bachmani riparius*	FE, SE	riparian areas on the San Joaquin River in northern Stanislaus County. dense thickets of wild rose, willows, and blackberries.		●		●		●								●				
American badger *Taxidea taxus*	SSC	most abundant in drier open stages of most shrub, forest, and herbaceous habitats, with friable soils. needs sufficient food, friable soils and open, uncultivated ground. preys on burrowing rodents. digs burrows.	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
San Joaquin kit fox *Vulpes macrotis mutica*	FE, ST	annual grasslands or grassy open stages with scattered shrubby vegetation. need loose-textured sandy soils for burrowing, and suitable prey base.	●	●	●	●	●	●						●	●	●		●		
Point Reyes jumping mouse *Zapus trinotatus orarius*	SSC	primarily in bunch grass marshes on the uplands of point reyes. also present in coastal scrub, grassland, and meadows. eats mainly grass seeds with some insects and fruit taken. builds grassy nests on ground under vegetation, burrows in winter							●			●						●		

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Table A-3 Special-status Fish Species by Region

Species	Status	Sacramento San Joaquin	North Coast	South Coast
Kern brook lamprey *Lampetra hubbsi*	SSC	+		
Green sturgeon Acipenser medirostris	FT[1]	+	+	
Arroyo chub *Gila orcutti*	SSC			+
Hitch *Lavinia exilicauda*	SSC[2]	+		+*
California roach *Lavinia symmetricus*	SSC	+	+	+*
Sacramento splittail *Pogonichthys macrolepidotus*	SSC	+		
Delta smelt *Hypomesus transpacificus*	SE, FT	+		
Longfin smelt *Spirinchus thaleichthys*	ST	+	+	
Eulachon *Thaleichthys pacificus*	SSC		+	
Coho salmon *Oncorhynchus kisutch*	ST[3], SE[4], FT[3], FE[4]		+	
Chinook salmon *Oncorhynchus tshawytscha*	ST[5], SE[6], FT[7], FE[8]	+	+	
Chum salmon *Oncorhynchus keta*	SSC	+	+	
Rainbow trout/Steelhead Oncorhynchus mykiss	FT[9], FE[10]	+	+	+
Coastal cutthroat trout *Oncorhynchus clarki*	SSC		+	
Sacramento perch *Archoplites interruptus*	SSC	+		
Russian River tule perch *Hysterocarpus traski*	SSC	+	+	
Tidewater goby *Eucyclogobius newberryi*	FE, SSC[11]	+	+	+

FE = Federally listed as Endangered
FT = Federally listed as Threatened
SE = State-listed as Endangered
ST = State-listed as Threatened

[1] Southern DPS
[2] Clear Lake subspecies only
[3] South Oregon/No. CA ESU
[4] Central CA Coast ESU
[5] Sacramento River Spring-run
[6] Winter-run
[7] California Coastal ESU, Central Valley spring-run
[8] Sacramento River winter-run
[9] Northern CA ESU, Central CA Coast ESU, South-Central CA Coast ESU, Central Valley ESU
[10] Southern CA ESU
[11] Populations in Orange Co. and south. Populations north of Orange Co. delisted

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Integrated Mosquito and Vector Management Programs

APPENDIX B

ECOLOGICAL & HUMAN HEALTH ASSESSMENT REPORT

Ecological & Human Health Assessment Report

Project Name	Integrated Mosquito and Vector Management Programs for Nine Districts
Date	June 2013, Revision 7

Prepared for:

Alameda County Mosquito Abatement District
Alameda County Vector Control Services District
Contra Costa Mosquito and Vector Control District
Marin/Sonoma Mosquito and Vector Control District
Napa County Mosquito Abatement District
Northern Salinas Valley Mosquito Abatement District
San Mateo County Mosquito and Vector Control District
Santa Clara County Vector Control District
Solano County Mosquito Abatement District

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Acronyms

µg/cm^2	microgram per square centimeter
2,4-D	2,4-Dichlorophenoxy acetic acid
AA-ITU	*Ae. aegypti* International Toxic Unit
ACMAD	Alameda County Mosquito Abatement District
ACVCSD	Alameda County Vector Control Services District
ae	acid equivalent
AI or a.i.	active ingredient
ALS	acetolactate synthesis
AMPA	aminomethylphosphonic acid
APEs	alkylphenol ethoxylates
ATP	adenosine triphosphate
BCF	bioconcentration factor
BCPC	British Crop Protection Council
BMP	Best Management Practice
Bs	Bacillus sphaericus
Bti	Bacillus thuringiensis subspecies israelensis
bw	body weight
Cal/EPA	California Environmental Protection Agency
CCMVCD	Contra Costa Mosquito and Vector Control District
CDPH	California Department of Public Health
CDPR	California Department of Pesticide Regulation
CEQA	California Environmental Quality Act
CFU	colony forming units
CNS	central nervous system
DCPA	chlorthal dimethyl
DDVP	Dichlorvos
di-acid or TPA	tetrachloroterephthalic acid
DOD	Department of Defense

EbC50	50% reduction of biomass
EC50	Median Effective Concentration
EEC	expected environmental concentrations
EPSP	enzyme 5-enolpyruvylshikimate 3-phosphate
ErC50	50% reduction of growth rate effects
IPCS	International Programme on Chemical Safety
IPM	Integrated Pest Management
ITUs	International Toxic Units
LC	lethal concentration
LC_{50}	median lethal concentration
LD	lethal dose
LD50	median lethal dose
LOAEC	lowest observed adverse effect concentration
LOAEL	lowest observed adverse effect level
LOC	Level of Concern
mo	months
MSMVCD	Marin/Sonoma Mosquito and Vector Control District
MVCAC	Mosquito and Vector Control Association of California Coastal Region
NCMAD	Napa County Mosquito Abatement District
NOAEC	no observed adverse effect concentration
NOAEL	no observed adverse effect level
NOEC	no observed effect concentration
NOEL	No observed effect level
NPIC	National Pesticide Information Center
NSVMAD	Northern Salinas Valley Mosquito Abatement District
PBO	Piperonyl Butoxide
PEIR	Programmatic Environmental Impact Report
PMDS	polydimethylsiloxane
PPE	personal protective equipment
ppm	parts per million
Programs	Integrated Mosquito and Vector Management Programs
REDs	reregistration eligibility decisions
RUP	restricted-use pesticide
SCCVCD	Santa Clara County Vector Control District
SCMAD	Solano County Mosquito Abatement District
SMCMVCD	San Mateo County Mosquito and Vector Control District
SWRCB	State Water Resources Control Board

TBEE	triclopyr butoxyethyl ester
TEA	triethylamine
TPA or di-acid	tetrachloroterephthalic acid
ULV	Ultra Low Volume
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
UV	ultraviolet
ww	wet weight

1 Executive Summary

The nine northern California Districts (members of the Mosquito Vector Control Association of California Coastal Region [MVCAC]) participating in this CEQA compliance effort engage in mosquito and other vector control activities to protect the public health in their respective Program Areas. These activities are being evaluated for compliance with the California Environmental Quality Act (CEQA) based on current CEQA statutes and Guidelines and recent case law. This draft technical report provides an evaluation of the potential hazards (and estimated risks) of the pesticide application activities used, and in some cases, planned, for vector control. The information provided by the Districts has been synthesized and evaluated to identify any potential environmental concerns due to use of potentially hazardous chemicals. This evaluation was based on a review of the documented characteristics of each chemical, including the efficacy, mode of action, candidate target species, reported toxicity to humans and wildlife, and likely fate and transport under application conditions. The information in this report is intended to be used to support the preparation of a Programmatic Environmental Impact Report (PEIR). The term pesticide as used herein refers to all modes of chemical and biological control, including insecticides, herbicides, and adjuvants unless otherwise indicated.

Each of the nine Districts provided extensive information about their pesticide use in support of this Ecological and Human Health Assessment including:

> Pesticides used by each District

> Types of application sites (e.g., habitat types)

> Number of treatments per application site

> Total amount used per treatment for each application site, based on seasonal uses

This information is summarized in Attachment A. This draft technical report provides results of the review and evaluation of 46 active ingredients used and potentially considered for future use by the Districts. The objective was to identify those that may pose potential human health or ecological concern when used by the Districts. Documented toxicity and environmental fate of the pesticides were reviewed and evaluated, based primarily on the active ingredient, and the results are summarized in Chapter 4 (Table 4-1).

The pesticide application scenarios that result in reasonable efficacy with minimal unwanted estimated risk are preferred and are the basis of Integrated Pest Management (IPM)/Integrated Vector Management (IVM) approaches practiced by the Districts.

Using the available information about the active ingredients reviewed, there were several overarching parameters that are known to adversely impact risk. Primary factors considered include the inherent toxicity and mode of action of the chemical. Other important factors that are considered include the possible transport and fate of the chemical in various media, the reported likely exposure routes, and documented ecological and human studies supporting the toxicity data. Several important parameters, such as the retention time (half-life) in various media are also considered, but are dependent on specific conditions at the time of application. Based on these criteria, several pesticides received additional discussion during the workshop with the nine Districts on February 20, 2013.

Using the approach discussed above, select active ingredients were identified (Table 1-1) and discussed during the workshop to supplement the information relevant to the evaluation of potential risk and contained in Chapter 4. Each of these pesticides exhibits at least one parameter that appears to drive potential risk, and the Districts provided additional information on measures employed to minimize potential risk.

Table 1-1 Active Ingredients Identified for Discussion

Active Ingredient	Vector	Potential Issue
Methoprene	Mosquitoes	Prevalent use; toxicity to aquatics and insects
Etofenprox	Mosquitoes	Toxicity to aquatic organisms; no synergist required
Bti	Mosquitoes	Prevalent use; public concerns
Pyrethrins	Mosquitoes/yellow jacket wasps	Prevalent use; requires synergist (PBO)
Resmethrin	Mosquitoes	Requires synergist (e.g., PBO); potential endocrine disruptor
Plant oils (coconut oil)/mix	Weeds/vegetation/mosquitoes	Contains low percentage of petroleum distillate (10%)
Plant oils/mineral oils	Weeds/vegetation/mosquitoes	Surfactants/adjuvants used to enhance the efficacy or application of post emergent herbicides.
Permethrin	Mosquitoes/yellow jacket wasps	Toxicity to aquatic organisms; potential endocrine disruptor
Lambda-cyhalothrin	Yellow jacket wasp	Toxicity to aquatic organisms; potential to bioaccumulate
Bromadiolone	Rats	Toxicity to non-target organisms including mammals, birds, aquatics
Difethialone	Rats	Toxicity to non-target organisms including mammals, birds, aquatics
Alkylphenol ethoxylates	Weeds/vegetation/mosquitoes	Surfactants/adjuvants used to enhance the efficacy or application of post emergent herbicides.
Glyphosate	Weeds/vegetation	Prevalent use; possible endocrine disruptor
Diuron	Weeds/vegetation	Prevalent use; toxicity to freshwater fish
Benfluralin	Weeds/vegetation	Toxicity to aquatics; potential for bioaccumulation/endocrine disruption

The toxicity and adverse effects information collected, reviewed and critiqued for each of the pesticide products evaluated in this document is based primarily on results of laboratory studies that are extrapolated to appropriate potential receptor species. In assessing the toxicity information in this document, it should be remembered that most toxicity data are derived from rigidly controlled laboratory animal studies designed to determine the potential adverse effects of the chemical under several possible routes of exposure. In these studies, the species of interest is exposed to 100 percent chemical at several doses to determine the lowest concentration resulting in a predetermined adverse effect (LOAEL) on numerous physiological and behavioral systems. The second component of these tests is to determine the highest concentration of chemical that results in no measurable adverse effect (NOAEL).

However, these laboratory tests are designed to document the effects of the chemical when there is a continuous, controlled exposure and do not realistically reflect the likely exposures or toxicity in the field application scenarios. In the field, animals can move around, are able to make selections of food and prey and often avoid sprayed areas completely. As such, the toxicity information is intended as guidance for determining the levels of applications that would not adversely impact non-target species. Because the applications are conducted under rigid Best Management Practices (BMPs), using the minimum effective pesticide application concentrations and do not result in continuous exposures, these laboratory derived estimates of potential risk are not appropriate for the actual exposures and effects in the field.

This document provides information in tables and appendices about the parameters used to evaluate 46 active ingredients and a summary of the ecological and human health issues that may indicate a potential concern when used for vector control.

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2 Introduction

This report provides an Ecological and Human Health Assessment of pesticides and herbicides contained in the Integrated Mosquito and Vector Management Programs (Programs) for nine mosquito abatement and/or vector control districts in northern California. The nine districts are: Alameda County Mosquito Abatement District (ACMAD), Alameda County Vector Control Services District (ACVCSD), Contra Costa Mosquito and Vector Control District (CCMVCD), Marin/Sonoma Mosquito and Vector Control District (MSMVCD), Napa County Mosquito Abatement District (NCMAD), Northern Salinas Valley Mosquito Abatement District (NSVMAD), San Mateo County Mosquito and Vector Control District (SMCMVCD), Santa Clara County Vector Control District (SCCVCD), and the Solano County Mosquito Abatement District (SCMAD). The Programs provide for mosquito and/or vector control activities within each District's Program Area. The nine District Program Areas include both the Service Areas within the Districts and the surrounding counties where the Districts may provide mosquito and/or other vector management services when requested by the adjacent county or district.

The immediate nine District Service Areas are located in the following nine counties of the state: Alameda, Contra Costa, Marin, Monterey, Napa, San Mateo, Sonoma, Solano, and Santa Clara. Control activities may also be provided in areas adjacent to the District Service Areas upon request of the adjacent jurisdictions to protect the health and safety of residents within the Program Area. Actions that would be taken within the nine Districts' Program Areas are the same types of actions undertaken within the Districts' Service Areas and in similar types of habitats or sites. Therefore, the nine District Program Areas addressed in this report also include the nine additional surrounding counties: Mendocino, Merced, Lake, Sacramento, San Benito, San Joaquin, Santa Cruz, Stanislaus, Yolo, and the portion of Monterey County south of the NSVMAD.

A health assessment has been conducted to evaluate the potential risks posed by the chemical treatments/pesticide and herbicide formulations to non-target organisms, including humans and sensitive ecological receptors. Pesticides and herbicides are handled separately but in parallel during the evaluation. The first level of investigation was a toxicity/hazards evaluation comprised of a comprehensive literature review for the active ingredients contained in the chemical products and formulations used for vector control. This evaluation was performed to support the Programmatic Environmental Impact Report (PEIR) for each District. Reviewed toxicity literature included peer-reviewed publications, California Department of Pesticide Regulation (CDPR) data and reports, United States Environmental Protection Agency (USEPA) reports, and California Department of Public Health (CDPH) reports. The processes employed for the evaluation and the selection of active ingredients to focus on are described below. Although this document is intended to address the active ingredients most likely to engender some perceived or real concern by the public and regulators, the report includes hazard information about all active ingredients representing products in use or planned for future use by the nine Districts represented in this report.

In general, application scenarios employed by the Districts represented in this report include several basic, yet critical, Best Management Practices (BMPs) to minimize and often negate any potential exposures that might result in unwanted adverse effects to non-target species. Additional integrated pest management (IPM) and BMP practices are utilized by each District.

The results of this assessment are based on assumptions about toxicity and mode of action derived from available information and data, including the published literature. In addition to the documented efficacy (toxicity) to target species and vectors, this assessment also considers the potential risk to sensitive non-target organisms inventoried in a variety of habitat types in the Northern California Coastal Region and presented in the Biological Resources Technical Report (PEIR Appendix A). Application scenarios and other data were evaluated to estimate the potential for exposures to sensitive non-target ecological

receptors. Some of the potential pesticide applications that might result in unacceptable estimated risk have been identified. While the majority of the active ingredients representing products used by the Districts are openly available and do not suggest an unacceptable risk, this review addresses the information and assumptions about possible use patterns and possible exposure issues.

2.1 General Issues Associated with the Current Pesticide Use

The Districts currently employ a combination of methods in their IPM programs for vector control, including the application of a variety of pesticide formulations by several mechanisms. These formulations, registered by the USEPA and California Environmental Protection Agency (Cal/EPA) are methodically applied by the Districts to minimize potential impacts to non-target receptors. However, the potential for impact to humans and ecological receptors from these chemicals was examined in order to provide evidence to support conclusions reached about their safety and proper use scenarios.

Application scenarios employed by the Districts represented in this report include several basic, yet critical, BMPs to minimize and often negate any potential exposures that might result in unwanted adverse effects to non-target species. Pesticide application safety is maximized by the Districts by:

> applications according to strict adherence to label instructions

> restricting applications to low wind conditions to minimize drift

> using Ultra Low Volume (ULV) applications whenever possible

> applications late at night when non-target species (e.g., bees, etc.) are not active

> observation and documentation of nearby water sources and adherence to buffer zones

> use of appropriate protective personal equipment (PPE) by applicators and field crews

> careful reporting and tracking of all pesticide uses by the District

> applications only on an “as needed” or “as appropriate” basis

Additional IPM and BMP practices tailored for each District are also utilized.

The objective of this report is to address and evaluate the potential for human and ecological hazards of application scenarios of the active ingredients contained in a variety of products and formulations used by the Districts in their efforts to control and abate mosquito and other vector infestations. The review of toxicity literature and environmental fate information focused on developing a scientific summary of the safety of these applications. If some level of concern or perception about unintended effects of the applications results from the evaluation, approaches will be developed to mitigate or prevent real or perceived adverse effects, including BMPs.

2.2 Human and Ecological Health Evaluations

2.2.1 Human Health Impact Evaluation

Pesticides used by the nine Districts were investigated to provide a preliminary toxicity assessment related to potential impacts to humans. Pesticide formulations, label recommendations, and application procedures were also reviewed to evaluate the potential likelihood for bioaccumulation and/or food item biomagnification. For each pesticide and herbicide evaluated, written explanations are provided regarding the physiochemical characteristics of the product, including absorption, metabolism, and elimination; and any other specific reported evidence of reproductive, developmental, or carcinogenic effects.

2.2.2 Ecological Health Impact Evaluation

A general hazard evaluation was conducted for the pesticides and herbicides used by the nine Districts and reported application scenarios. The potential impacts to representative invertebrates, wildlife, fish,

and aquatic plants were considered, and then evaluated using a hazard evaluation of the active ingredients.

The evaluation included a review and evaluation of the current toxicity literature (available field and lab studies) relevant to ecological receptor impacts, and information relevant to the ultimate environmental fate for these active ingredients. The behavior of these materials in the environment (including fate and transport) are evaluated for chemicals reportedly handled by Districts' staffs. The potential effects could be caused by the active ingredients' mechanism of action (potential toxicity), as well as the potential for bioconcentration, bioaccumulation, or biomagnification.

The hazard and risk evaluations of the pesticides and herbicides used by the nine Districts were conducted in separate, but related phases. In the first phase, the objective was to determine and document the chemical characteristics and potential for adverse impacts when used as intended by the Districts. During subsequent evaluation for the PEIR, a tiered sorting technique was used to rank each chemical (active ingredient) according to several criteria: 1) The documented toxicity of the active ingredient as indicated in the open literature; 2) The target species by vector; 3) The non-target species and biota that are likely to be exposed; 4) The likely media to be exposed for each chemical; and 5) Possible sensitive seasonal exposure conditions (Figure 1).

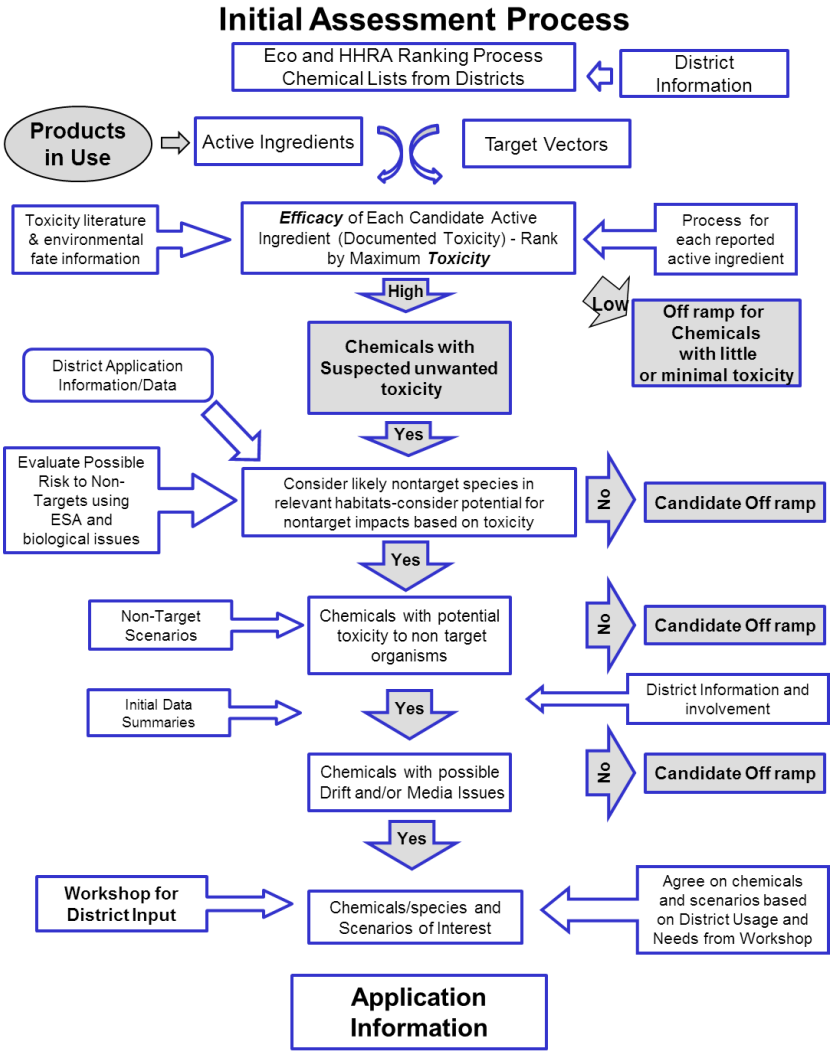

Figure 1 Process to Identify Chemicals for Further Discussion

2.3 Initial Approach

The evaluations conducted for each active ingredient provide a general indication of the potential for human or ecological risk and possible adverse effects to non-target organisms.

This approach was used to develop the list of chemicals used by each District that should be of little or no concern when used according to product labels and to identify those (if any) that may be problematic in certain use scenarios. Pesticides are first reviewed for target vector efficacy, based on both documented laboratory and field studies. Pesticide efficacy is of prime importance in the evaluations, but efficacy is contrasted to potential adverse impacts in the determination of the safety of use. To provide an indication of the possible adverse effects of each pesticide, the characteristics of its application scenarios are scored for relative "safety".

> Pesticides proposed for use with low potential exposure to people including sensitive populations (i.e., children, the elderly).

> Pesticides proposed for use with very low or minimal toxicity (hazard) based on the above analyses.

> Pesticides with the least potential for toxicity when used in or near important habitats for sensitive or non-target species.

> Pesticides showing little or no extraordinary seasonal potential impacts.

2.3.1 Components of a Review

2.3.1.1 Problem Formulation

> Ecological effects characterization

> Identification of the environmental setting and pesticide of interest

> Characterization of pesticide mechanism of action

> Possible transport pathways

> Categories of receptors likely affected

> Identification of application scenarios provided by the Districts

2.3.1.2 Exposure Estimates

> Assumptions about potential exposures, including extent, timing and quantity

> Assumptions about potential species that might be exposed

2.3.1.3 Basic Risk Estimates

This information was used to:

> Identify likely uncertainties in the exposures

> Develop ranges of potential effects using "what if" parameter estimates.

> Determine estimate of risk needed to collect more information

The results of the evaluation for each of the pesticides of interest were used to qualitatively assess the potential for adverse effects of each active ingredient and select candidates for additional evaluation and characterization. These results are summarized immediately following discussion of environmental fate and toxicity for each pesticide throughout Chapter 4. Final conclusions and recommendations are included in Chapter 5.

The pesticide application scenarios that should result in low or "acceptable" results for the estimated risk will remain in the suite of potential control options while those with higher estimated risk estimates are identified. The process is graphically described in the following flow diagram (Figure 2).

At the conclusion of the initial evaluations, and in conjunction with the District managers, the results and possible recommendations for use scenarios based on acceptable risk estimates were the topic of a workshop conducted on February 20, 2013. The objective of the workshop was to discuss, review, and agree to the list of the active ingredients that should be included in this report and information about many of the BMPs used.

Safety evaluations generally follow the USEPA guidance (Figure 2) for pesticide evaluations, with a focus on the relevant uses and exposures identified and agreed upon during the workshop.

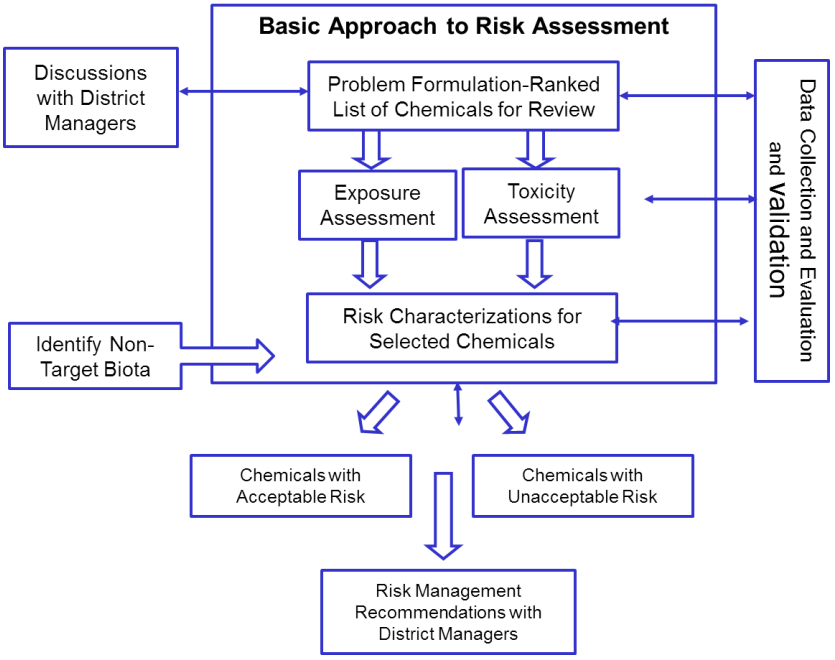

Figure 2 Process Used by USEPA to Evaluate Potential Risk for Chemicals

2.4 Approach to Refinement

The pesticide application scenarios that result in low or acceptable estimated risk as determined in the initial review of hazard information were categorized as lower potential risk, while others with higher potential estimated risk are identified and discussed with a focus on District-specific information about BMPs employed by staff and applicators. The process includes the following:

> Development of the relationships that describe the type of pesticides/herbicides used by the Districts against the target pest(s), the locations of intended uses (water bodies, grasses, forests, urban, residential, etc.), and the likely human and wildlife populations that might be inadvertently exposed.

> Evaluation of the inherent hazard (toxicity) of the pesticide(s)/herbicide(s) to non-target receptors (humans and wildlife).

> As a subsequent task in the PEIR, consider the potential exposure of humans and non-target species to each of the pesticides/herbicides based on the application scenarios, the concentrations used, and the likelihood that the application will reach or contact any populations of concern.

> The information in the PEIR provides estimates of potential "risk" and possible safety issues for each of the typical pesticide application scenarios.

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3 Vector Control Chemical Categories

The chemical products reported by the Districts, application scenarios, and potential new products and formulations for future use were obtained during project initiation and preparation of the PEIR Project Description. Application information provided by the Districts included the number of treatments and total amount applied of each product to specific habitat types during four quarters from Summer 2011 through Spring 2012 (see Attachment A). These data were integral for elucidating the estimated loading and potential exposures to different habitats that support non-target organisms. The evaluation focused on the active ingredients of the products/formulations. The target organisms and primary modes of action for the pesticide and herbicide active ingredients are described below. Tables 3-1 and 3-2 present the pesticide (non-herbicide) and herbicide products, respectively that are currently in use containing active ingredients reported here and the number of Districts using that product.

Table 3-1 Pesticide Products Containing Reported Active Ingredients

Product	Active Ingredient	Vector	Number of Districts
Agnique MMF	Biodegradable Alcohol Ethoxylated Surfactant	Mosquito	6
Agnique MMF G	Biodegradable Alcohol Ethoxylated Surfactant	Mosquito	3
Altosid Briquets 30-Day	Methoprene	Mosquito	6
Altosid Liquid Larvicide SR5	Methoprene	Mosquito	5
Altosid Liquid Larvicide Concentrate (SR20)	Methoprene	Mosquito	5
Altosid Pellets	Methoprene	Mosquito	7
Altosid Pellets WSP	Methoprene	Mosquito	3
Altosid SBG Single Brood Granule	Methoprene	Mosquito	2
Altosid XR-Briquets	Methoprene	Mosquito	7
Altosid XR-G	Methoprene	Mosquito	4
Astro®, Ortho® products, Bonide® products, Tengard® products, etc.	Permethrin	Yellow jacket wasp	1
Bell Terad 3 Blox	Cholecalciferol	Rat	1
BVA-2	Petroleum Distillate	Mosquito	7
Clarke Biomist 4 + 12 ULV	Permethrin and Piperonyl Butoxide (PBO)	Mosquito	1
Contrac 8 oz blk	Bromadiolone	Rat	1
Contrac All-Weather Blox	Bromadiolone	Rat	2
Contrac Super Blox	Bromadiolone	Rat	2
Delta Dust	Deltamethrin	Yellow jacket wasp	2
Ditrac Blox	Diphacinone	Rat	2
Ditrac Tracking Powder	Diphacinone	Rat	1

Table 3-1 Pesticide Products Containing Reported Active Ingredients

Product	Active Ingredient	Vector	Number of Districts
Drione	Pyrethrin and Piperonyl Butoxide and Amorphous Silica Gel	Yellow jacket wasp	5
EcoExempt IC2	Rosemary Oil	Mosquito	1
FirstStrike Soft Bait	Difethialone	Rat	2
FourStar 180 Day Microbial Briquets	*Bacillus sphaericus* and *Bacillus thuringiensis israelensis*	Mosquito	4
FourStar 45 Day Microbial Briquets	*Bacillus sphaericus* and *Bacillus thuringiensis israelensis*	Mosquito	4
FourStar 90 Day Microbial Briquets	*Bacillus sphaericus* and *Bacillus thuringiensis israelensis*	Mosquito	2
FourStar SBG (Single Brood Bti Sand Granule)	*Bacillus thuringiensis israelensis*	Mosquito	1
Golden Bear 1111	Aliphatic Petroleum Hydrocarbons	Mosquito	4
Kontrol 4-4	Permethrin and PBO	Mosquito	1
MetaLarv SP-T	Methoprene	Mosquito	1
MGK Pyrocide 7396	Pyrethrins and PBO	Mosquito	4
Natular 2EC	Spinosad	Mosquito	2
Natular G30	Spinosad	Mosquito	3
Natular XRT	Spinosad	Mosquito	1
Permanone	Permethrin and PBO	Mosquito	1
Pyrenone 25-5	Pyrethrins and PBO	Mosquito	5
Pyrocide Mosquito Adulticiding Concentrate for ULV Fogging 7067	Pyrethrins and PBO	Mosquito	1
Scourge 18% + 12%	Resmethrin and PBO	Mosquito	1
Skeeter Abate	Temephos	Mosquito	2
Spectracide Pro®	Tetramethrin and Permethrin and PBO	Yellow jacket wasp	1
Spectracide®	Prallethrin and Lambda-cyhalothrin	Yellow jacket wasp	1
Summit B.T.I. Briquettes	*Bacillus thuringiensis israelensis*	Mosquito	1
Teknar HP-D	*Bacillus thuringiensis israelensis*	Mosquito	2
Teknar SC	*Bacillus thuringiensis israelensis*	Mosquito	1
VectoBac 12AS	*Bacillus thuringiensis israelensis*	Mosquito	5
VectoBac G	*Bacillus thuringiensis israelensis*	Mosquito	5
VectoBac GS Biological Larvicide	*Bacillus thuringiensis israelensis*	Mosquito	1
VectoBac Technical Powder Biological Larvicide	*Bacillus thuringiensis israelensis*	Mosquito	1
VectoBac WDG Biological Larvicide	*Bacillus thuringiensis israelensis*	Mosquito	1

Table 3-1 Pesticide Products Containing Reported Active Ingredients

Product	Active Ingredient	Vector	Number of Districts
VectoLex CG	*Bacillus sphaericus*	Mosquito	7
VectoLex WDG	*Bacillus sphaericus*	Mosquito	4
VectoLex WSP	*Bacillus sphaericus*	Mosquito	5
VectoMax CG	*Bacillus sphaericus* and *Bacillus thuringiensis israelensis*	Mosquito	3
VectoMax WSP	*Bacillus sphaericus* and *Bacillus thuringiensis israelensis*	Mosquito	2
Wasp-Freeze	Phenothrin and Trans Allethrin	Yellow jacket wasp	3
Zenivex E4	Etofenprox	Mosquito	4
Zenivex E20	Etofenprox	Mosquito	5

Table 3-2 Herbicide Products Containing Reported Active Ingredients

Product	Active Ingredient	Vector	Number of Districts
Alligare Dithiopyr 40	Dithiopyr	Weed	1
Alligare Glyphosate 4-Plus	Glyphosate	Weed	1
Alligare Glyphosate 5.4	Glyphosate	Weed	1
Alligare Imazapyr 2 SL	Imazapyr	Weed	1
Alligare Oryzalin 4	Oryzalin	Weed	1
Alligare Triclopyr 3	Triclopyr	Weed	1
AMVAC Dacthal	DCPA	Weed	1
Aquamaster	Glyphosate	Weed	3
Balan	Benefin	Weed	1
Blazon Pattern Indicator	Polymeric Colorant (proprietary)	Weed	2
Buccaneer	Glyphosate	Weed	1
BullsEye Pattern Indicator	Proprietary Colorant	Weed	2
Competitor	Modified Plant Oil	Weed	2
Dacthal	DCPA	Weed	1
Dimension Ultra 40WP	Dithiopyr	Weed	1
Ecomazapyr 2 SL	Imazapyr	Weed	1
Garlon-3A	Triclopyr	Weed	1
Green Light Amaze XL 2G	Benefit, Oryzalin	Weed	2
Habitat	Imazapyr	Weed	2
Imazapyr 4-SL	Imazapyr	Weed	1

Table 3-2 Herbicide Products Containing Reported Active Ingredients

Product	Active Ingredient	Vector	Number of Districts
Karmex XP	Diuron	Weed	1
Liberate	Lecithin, methyl esters of fatty acids, alcohol ethoxylate	Weed	1
Monterey Nutgrass “Nihilator	Bentazon (sodium salt)	Weed	1
Monterey Turflon Ester, Turflon, Garlon 3®, Renovate®	Triclopyr	Weed	1
Monterey Weed Whacker	2,4-DP (dimethylamine salt)	Weed	1
MOR-ACT	Paraffin base petroleum oil	Weed	1
MSO	Methylated seed oil of Soybean	Weed	1
No Foam A	Alkyl Phenol Ethoxylate / Isopropanol	Weed	1
No Foam Defoamer	Polydimethylsiloxane & Silicon	Weed	1
Oust XP	Sulfometuron Methyl	Weed	2
Pennant Magnum	Metolachlor	Weed	1
Polaris	Imazapyr	Weed	2
Pro-Spreader Activator	Alkyl Phenol Ethoxylate / Isopropanol	Weed	2
R-11 Spreader Activator	Alkyl Phenol Ethoxylate / Butyl alcohol	Weed	1
Renovate 3	Triclopyr	Weed	1
Reward	Diquat dibromide	Weed	1
Roundup Pro Max®	Glyphosate	Weed	2
Roundup Pro®	Glyphosate	Weed	3
Roundup®	Glyphosate	Weed	1
Rodeo®	Glyphosate	Weed	1
RoundupMax	Glyphosate	Weed	1
Scotts Halts Crabgrass Preventer	Pendimethalin	Weed	1
Trimec Lawn Weed Killer, Spectricide® Weed Stop®, Ortho® Weed-b-Gon®, Weed Killer for Lawns, Bayer Advanced™ Southern Weed Killer	2,4-D (2,4-dichlorophenoxy acetic acid)	Weed	1
Tripleline Foam-Away	Polydimethylsiloxane	Weed	1
Turf Trax Blue	Polymeric Colorant (proprietary)	Weed	1
Turfgro NIS	Ethanol 2,2-oxybis	Weed	1
Vigoro Crabgrass Preventer, Monsanto Dimension®	Dithiopyr	Weed	1

3.1 Mosquito Control

3.1.1 Adulticides

Adulticides are generally applied as aerosols using ultra-low-volume (ULV) techniques. Aerial and ground application techniques are used to distribute the insecticides. Adulticide treatments are most frequently timed to correspond with mosquito activity (flying) when exposure is greatest to the insecticide aerosol mist (dusk to dawn) and granular material. In addition, residual barrier treatment applications are used in mosquito resting areas and migratory stops. These treatments are usually applied as large liquid droplets with a sprayer during daylight hours. The primary objective of this type of treatment is the temporary prevention of re-infestation.

3.1.1.1 Pyrethroids

Pyrethroids are synthetic analogs of the naturally occurring pyrethrins (which are from the Chrysanthemum plant) and have similar neurological effects on target organisms. These compounds cause rapid mortality of adult mosquitoes by interfering with sodium channel function in the nervous system.

3.1.1.2 Pyrethrin

Pyrethrins are naturally occurring products distilled from the flowers of Chrysanthemum species. Pyrethrins are composed of a mixture of six compounds: pyrethrin I and II, cinerin I and II, and jasmolin I and II. Pyrethrins are contact poisons that can quickly penetrate the neural system. Pyrethrins act by causing a persistent activation of the sodium channels on insect neurons.

3.1.1.3 Organophosphates

Organophosphates, such as naled, although not currently used by the Districts, is discussed as a possible material for use and is defined in Section 4.2 of this document and in Table 6-1.

3.1.2 Larvicides

Larvicides are used to manage immature life stages of mosquitoes including larvae and pupae in aquatic habitats. Temporary aquatic habitats are usually targeted because permanent water bodies generally support natural mosquito predators such as fish. The larvicides are applied using ground application equipment, fixed wing aircraft and rotary aircraft.

3.1.2.1 Contact Pesticides

(S)-Methoprene is a hormone analogue that interferes with insect larval development (growth regulator). This chemical does not exhibit the nonspecific target effects of neurological toxins such as pyrethrin.

Spinosad is a natural insecticide derived from the fermentation of a common soil microorganism, *Saccharopolyspora spinosa*. Spinosad alters nicotine acetylcholine receptors in insects causing constant involuntary nervous system impacts ultimately leading to paralysis and death.

3.1.2.2 Surface Active Agents

Petroleum- and plant-based (ethoxylated isotearyl alcohols) oils are used as surface-active agents effective against larvae and pupae. These oils are effective against these immature life stages when inhaled at the water surface or by physically forming a surface film that drowns the mosquito. These treatments may also be effective against adult mosquitoes during adult emergence.

3.1.2.3 Stomach Toxins

Bacterial larvicides such as Bti (*Bacillus thuringiensis israelensis*) and Bs (*Bacillus sphaericus*) are highly selective (for mosquitoes) microbial pesticides that when ingested, produce gut toxins that cause

destruction of the insect gut wall leading to paralysis and death. These microbial agents are delivered as endospores in granular, powder, or liquid concentrate formulations.

3.2 Other Vector Control

There are a variety of pesticides used for the control of vectors including rats, ticks, yellow jackets wasps, and weeds.

3.2.1 Rats

Toxic baits may be used to achieve adequate control of rats when populations become too large to impact using traps. Federal EPA changes to rodenticide regulations occurred in 2011 (http://www.epa.gov/pesticides/mice-and-rats/) in an effort to reduce the hazard to wildlife, pets and children. The use of baits is confounded by the potential for food web transfer of the bait to other trophic level receptors that might also encounter and eat the raw bait or predate an animal that has ingested the bait.

3.2.1.1 Anticoagulant Rodenticides

Anticoagulant rodenticides cause fatal internal bleeding by thinning the animal's blood and preventing clotting. Two groups of anticoagulants exist including the older "first-generation" compounds effective if consumed over multiple doses and the newer "second-generation" compounds, which are fatal after a single dose. The acute toxicity of second-generation rodenticides presents a greater hazard to wildlife, pets, and children. Products containing second-generation active ingredients are no longer permitted to be sold to the general public. These products remain available to professional pest control personnel, however.

3.2.1.2 Other Rodenticides

Three other rodenticides are available for use in California. Bromethalin and cholecalciferol are chronic rodenticides and achieve successful results similar to those of anticoagulants. Multiple feeding doses are required to induce mortality of rodents. Bromethalin is a neurotoxin, which damages the central nervous system (CNS). Cholecalciferol produces hypercalcemia leading to renal failure and CNS depression, among other generalized symptoms of toxicity. Zinc phosphide is an acute toxicant and causes death within a few hours of consumption. Often, use of this compound requires "pre-baiting" prior to addition of the chemical to rat bait in order to achieve adequate bait acceptance. Zinc phosphide is used to lessen impact on predators in the food web.

3.2.2 Yellow Jacket Wasps

Aerosol insecticides and dusts can be effective when applied directly to yellow jacket wasp nest openings. Most conventional pesticides are either pyrethrin or pyrethroids. Synthetic pyrethroid insecticides act as sodium channel modulators and very effective when used against wasps. Pyrethrin compounds act as paralytics and will immobilize the insect temporarily and may cause mortality.

Short-residual pyrethroids include allethrin, phenothrin, resmethrin, sumithrin, and tetramethrin. Longer-lasting pyrethroid insecticides include lambda-cyhalothrin, deltamethrin, and permethrin.

3.2.3 Tick Control

Although tick surveillance is the recommended method to monitor this vector, there are several pesticides that can be useful if an unwanted tick infestation should occur. Ticks (e.g., deer ticks) act as vectors for bacterial pathogens, such as *Borrelia burgdorferi*, the agent of Lyme disease. Currently, deltamethrin is the only active ingredient that has been used for tick control.

3.2.4 Weed Vegetation Control

Herbicides are classified in several ways. Pre-emergent herbicides are applied to the soil to prevent seedlings from germinating and emerging. Post-emergent herbicides are applied after seedlings have

emerged and control actively growing plants via contact damage or systemic impacts. Contact herbicides cause physical injury to the plant upon contact. Systemic herbicides damage the internal functioning of the plant.

3.2.4.1 Herbicides for Broadleaves

Herbicides for use against annual broadleaf weeds are generally post-emergent applications that affect the plant systemically. 2,4-Dichlorophenoxy acetic acid (2,4-D), imazapyr, triclopyr, sulfometuron methyl, bentazon, diuron, oryzalin, DCPA, dithiopyr, and pendimethalin are examples of broadleaf herbicides.

3.2.4.2 Herbicides for Grass Weeds

Herbicides used against annual grasses (e.g. crabgrass, foxtail, etc.) are pre-emergent applications containing ingredients such as pendimethalin. Weed grasses can be treated with post-emergent applications; however, these tend to be less effective than pre-emergent treatments. Some can be eliminated with spot treatments of potent, nonselective herbicides such as glyphosate, which act systemically by inhibiting the synthesis of the aromatic amino acids phenylalanine, tyrosine, and tryptophan.

3.2.4.3 Herbicides for Sedges

Spot treatments with glyphosate are also useful in eliminating sedges (e.g. yellow and purple nutsedge, green kyllinga, etc.). Pre-emergent materials such as DCPA are effective at killing seeds of green kyllinga, but ineffective against nutsedges.

3.2.4.4 Aquatic Invasive Species

Imazapyr is an imidazolinone herbicide (e.g., Habitat®) that inhibits acetolactate synthesis (ALS), an enzyme necessary for the production of essential amino acids in plants. This class of chemicals includes systemic, nonselective, pre- and post-emergent herbicides used for the control of terrestrial and aquatic weeds (e.g., imidazolinoes, pyrimidinyl thiobenzoates, sulfonylureas, sulfonyl amino carbonyl triazolinone, and triazolopyrimidines). In California, these compounds have been used to combat the invasive purple loosestrife plant in aquatic environments. Unfortunately, this species and others appear to have developed resistance to the ALS-inhibiting family of chemicals. In addition, the non-target impacts of these compounds may cause negative effects to threatened or endangered plants.

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4 Evaluation of Active Ingredients-Results

This section presents the supporting information and results of the evaluation that will be incorporated into the each District's PEIR. Information below includes a description of the chemical compound, general pesticide use/application techniques, mode of action, toxicity, environmental fate and transport, and potential impact assessment.

Several insecticides were previously evaluated in the Monitoring Plan for Mosquito Larvicides and Adulticides (2011) prepared by MVCAC. Descriptions of these compounds, pesticide use patterns, and environmental fate and transport were updated in this document as needed. Source information for the fate and transport data include USEPA reregistration eligibility decisions (REDs), USEPA risk evaluations, DPR fate reviews, fate reviews from the scientific community, and data provided by manufacturers. Toxicity information was included for select compounds, including details relevant to ULV applied mosquito adulticides. Table 4-1 provides a summary of the toxicity and fate and transport information associated with the active ingredients. In addition, toxicity values for a variety of receptors (human and ecological) are presented later in Chapter 6 in Table 6-1.

The toxicity data included in the numerous tables and charts in this document are generally derived from rigidly controlled laboratory animal studies designed to determine the potential adverse effects of the chemical under several possible routes of exposure. In these studies, the species of interest is exposed to 100 percent chemical at several doses to determine useful information such as the lowest concentration resulting in a predetermined adverse effect (LOAEL) on numerous selected physiological and behavioral systems. The second component of these tests is to determine the highest concentration of chemical that results in no measurable adverse effect (NOAEL).

However, these, and other, coordinated and focused laboratory tests are designed to document the effects of the chemical when a continuous, controlled, exposure exists and do not realistically reflect the likely exposures or toxicity of District field application scenarios. As such, the toxicity information is intended as an overview of potential issues and guidance for understanding the maximum exposure levels of applications that would not adversely impact humans or non-target plant and animal species.

Although the regulatory community uses this basic information to provide a relative comparison of the potential for a chemical to result in unwanted adverse effects and this information is reflected in the approved usage labels and MSDSs, in actual practice, the amounts actually applied in the District's Program Area are substantially less than the amounts used in the laboratory toxicity studies. Because of the large safety factors used to develop recommended product label application rates, the amount of chemical resulting in demonstrated toxicity in the laboratory is much higher than the low exposure levels associated with an actual application. The application concentrations consistent with the labels or MSDSs are designed to be protective of the health of humans and other non-target species (i.e., low enough to not kill them, weaken them, or cause them to fail to reproduce). However adverse effects may still occur to some non-target organisms.

Chapter 4 provides the results of this review, evaluation, and synthesis of data for each of the selected pesticides in use by the nine Districts. The analysis provides informative results for the Districts that are interested in an evaluation of the potential efficacy and effects of their respective pesticide treatment scenarios. In each case, the evaluations include consideration of four primary parameters:

> Efficacy to target vectors;

> Documented acute and chronic ecological and human toxicity (where available);

> Known media/habitat use scenarios for each pesticide and for each District; and

> Evaluation of potential non-target biota that might be adversely impacted and the associated exposure level.

Using these parameters, the process results in a functional evaluation of the likelihood that each pesticide application scenario (scenarios) could be used safely. At the conclusion of each evaluation process, those scenarios that appear to result in potential unwanted (adverse) impacts were subjected to additional evaluation based on generally accepted "risk evaluation" guidelines.

4.1 Pyrethrin, Pyrethroids, Pyrethroid-like Compounds and Synergists

Pyrethrins are natural organic compounds derived from the plant *Chrysanthemum cinerarifolium*. These compounds have been known for their insecticidal properties for many centuries, and it is believed the Chinese used the powder of crushed chrysanthemum plants as an insecticide as early as 1000 BCE (Gunasekara 2005). Pyrethrins affect the nervous system of insects causing paralysis and death. Pyrethrins are photo unstable, rapidly degrading in the presence of light.

Pyrethroid insecticides are synthetic compounds that are chemically similar to the pyrethrins but have been modified to increase stability and activity against insects. Some synthetic insecticides are similar to pyrethroids, such as etofenprox, but have a slightly different chemical composition. First generation or "Type I" photosensitive pyrethroids include d-allethrin, phenothrin (sumithrin), prallethrin, resmethrin, and tetramethrin. Typically, these pyrethroids are used indoors and around residential areas. The newer second-generation pyrethroids are mostly "Type II" pyrethroids. Chemically, Type II pyrethroids are distinguished from Type I pyrethroids by the presence of anα-cyano group in their structure. The active ingredients that fall into this group include deltamethrin, esfenvalerate, lambda-cyhalothrin, and permethrin. Type II pyrethroids are more toxic (than Type I pyrethroids) because they are less photosensitive and persist longer in the environment.

Pyrethroids affect insect neuroactivity by binding to a protein at the nerve fiber that regulates the voltage-gated sodium channel. This can delay the closing of sodium channels and/or cause a persistent activation of the sodium channels. This often results in repetitive activity (Type I pyrethroid) or blockage of nerve conduction (Type II pyrethroid).

Synergists are substances that enhance the activity of another substance. Piperonyl butoxide (PBO) is a common synergist that is combined with pyrethrins and a number of synthetic pyrethroids that are used in many vector management programs as well as sprays that are available to the general public.

4.1.1 Pyrethrins

Pyrethrins are naturally occurring products distilled from the flowers of Chrysanthemum species. Pyrethrins are composed of a mixture of six compounds: pyrethrin I and II, cinerin I and II, and jasmolin I and II. Pyrethrins are contact poisons that can quickly penetrate the neural system. Pyrethrins act by causing a persistent activation of the sodium channels on insect neurons. Although pyrethrins have an effective "knockdown" action (induction of temporary paralysis), they do not necessarily have high killing properties when used alone. In order to delay the metabolic action (inhibition of microsomal enzymes) so that a lethal dose is assured, the synergist piperonyl butoxide (PBO) is added to mosquito adulticides (USEPA 2006f).

Pyrethrins were first registered in the U.S. for use as an insecticide in the 1950s. Pyrethrins are used on many agricultural crops; on livestock and animal husbandry premises; for treatment of commercial and industrial facilities and storage areas where raw and processed food/feed commodities are stored or processed; and for wide-area mosquito abatement in areas that include aquatic habitats. They are also used on outdoor household areas, pastureland, aquatic area or standing water, and for hospitals, recreational areas, ULV applications, and mosquito abatement programs (USEPA 2006f, CDPR 2010a).

Table 4-1 Summary Characteristics of Active Ingredients

Active Ingredient: Chemical or Biological	Fate & Transport Air (Volatility)	Fate & Transport Water	Fate & Transport Soil	Mode of Action	Human Health[1]	Ecological Health[1]
Pyrethrins	> n/a	> Major route of dissipation is photolysis. > Quickly adsorb to suspended solids in the water column and partition to the sediment.	> Major route of dissipation is photolysis. > Pyrethrins are likely to persist under anaerobic conditions. > Generally immobile in soils, therefore the potential to leach to groundwater is low.	> Insecticide: > Naturally occurring products distilled from Chrysanthemum spp. flowers. > Contact poisons that act by causing persistent activation of the sodium channels on insect neurons resulting in “knock-down” agent. > The synergist PBO is added to ensure a lethal dose.	> Low to moderate acute toxicity via the oral, dermal, and inhalation routes. > Chronic exposure effects include neurobehavioral, thyroid, and liver effects.	> Very highly toxic to freshwater fish and invertebrates. > Practically nontoxic to birds.
Allethrins and d-trans allethrin	> When used in coils and mats, allethrins are released into the air where they will be degraded by sunlight or be distributed in low concentrations to nearby surfaces.	> Not water soluble. > Photolysis half-life is <8 hrs.	> Adheres moderately to soil containing organic matter.	> Insecticide: Synthetic pyrethroid structurally similar to cinerin I in naturally occurring pyrethrum. > d-trans stereoisomer is the most insecticidally active. > Typically used as a “knock-down” agent. > Synergists such as PBO are added to ensure a lethal dose.	> Slightly to moderately acute toxicity via oral, dermal, and inhalation routes. > Toxicity varies with the amounts of different isomers present. > Not known to cause reproductive, teratogenic, mutagenic, or carcinogenic effects to mammals.	> Highly toxic to fish and invertebrates. > Very toxic to non-target insects. > Practically nontoxic to birds. > Bioaccumulation potential is unknown.
Phenothrin (sumithrin or d-phenothrin)	> n/a	> Low water solubility. > Major routes of dissipation are photolysis and anaerobic metabolism.	> High affinity for binding to soils and moderate persistence in surface soils. > Low leaching potential, therefore phenothrin is relatively immobile in soils or sediments. > Moderately persistent under aerobic conditions and persistent under anaerobic conditions.	> Insecticide: Adult mosquitoes.	> Low acute toxicity by oral, dermal, and inhalation routes. > Mild eye irritant but not a skin irritant.	> Highly toxic to fish and freshwater invertebrates. > Practically nontoxic to birds.
Prallethrin	> n/a	> Major route of dissipation is photolysis.	> Major route of dissipation is photolysis. > Readily sorbs to soils and sediments.	> Insecticide: Synthetic pyrethroid with fast “knock-down” activity against insect pests. > Has a neural exciting effect on mosquitoes. > In California, prallethrin is combined with phenothrin in the product Duet (the only prallethrin adulticide used in California).	> Low to moderate acute toxicity via oral, dermal, or inhalation routes. > Mild eye irritant but not a skin irritant.	> Highly toxic to fish and freshwater invertebrates. > Practically nontoxic to birds. > Very toxic to honey bees. > Low toxicity to algae.
Deltamethrin	> n/a	> Degrades via hydrolysis, photolysis, and microbial action. > May persist in aquatic environments, particularly in the sediment.	> Most persistent in soils with high clay or organic matter content. > Moderately to highly persistent in terrestrial environments.	> Insecticide: Synthetic pyrethroid. > Induce long-lasting inhibition of the sodium ion channel activation gate, resulting in repetitive nerve signals in sensory organs, nerves, and muscles.	> Low to moderate acute toxicity via oral, dermal, or inhalation routes. > Chronic exposure of humans results in choreoathetosis, hypotension, prenatal damage, and shock. > No reported teratogenic, mutagenic, or carcinogenic effects.	> Very highly toxic to fish and invertebrates. Potential bioaccumulation in fish. > Practically nontoxic to birds. > Nonselective insecticide and is highly toxic to non-target insects, including honey bees.

[1] Toxicity levels (e.g., slight, low, moderate, high, etc.) are used prevalently in the published literature but are not standardized or representative of specific criteria. They qualitatively describe toxicity in relative terms.
n/a = not applicable

Table 4-1 Summary Characteristics of Active Ingredients

Active Ingredient: Chemical or Biological	Fate & Transport Air (Volatility)	Fate & Transport Water	Fate & Transport Soil	Mode of Action	Human Health[1]	Ecological Health[1]
Esfenvalerate	> n/a	> Practically insoluble in water. > Extremely hydrophobic. > When present in surface water, expected to be bind to suspended particulates and organic matter. > Degrades via photolysis and aerobic metabolism.	> Strong tendency to bind to soil. > Relatively immobile in soil and has low tendency to leach. > Degrades via photolysis and aerobic metabolism.	> Insecticide: > Broad spectrum, nonselective, voltage-dependent sodium-channel agonist. > Causes repetitive firing of neurons.	> Moderately toxic via acute routes. > Possible endocrine-disruptor.	> Highly toxic to fish and aquatic invertebrates. Bioaccumulates rapidly in fish. > Moderately toxic to birds. > Highly toxic to honey bees.
Lambda-cyhalothrin*	> n/a	> Extremely hydrophobic and rapidly adsorbs to soils and sediments. > Primary degradation pathways include photolysis and aerobic metabolism.	> Primary degradation pathways include photolysis and aerobic metabolism.	> Insecticide: Synthetic pyrethroid. > Induces long-lasting inhibition of the sodium ion channel activation gate, resulting in repetitive nerve signals in sensory organs, nerves, and muscles.	> Moderately toxic via acute oral, dermal, and inhalation routes. > Mild eye irritant but not a skin irritant.	> Highly toxic to fish. Potential to bioaccumulate in fish. > Low toxicity to birds. > Highly toxic to honey bees.
Resmethrin	> n/a	> Primary degradation pathways include photolysis and aerobic metabolism.	> Primary degradation pathways include photolysis and aerobic metabolism. > Low mobility in soil/sediments. > Environmentally persistent in absence of light.	> Insecticide: Synthetic pyrethroid. > Induces long-lasting inhibition of the sodium ion channel activation gate, resulting in repetitive nerve signals in sensory organs, nerves, and muscles.	> Low toxicity via acute oral, dermal, and inhalation routes. > Possible endocrine-disruptor.	> Highly toxic to fish and aquatic invertebrates.
Tetramethrin	> n/a	> Not persistent in the environment. > Decomposes rapidly by photolysis and hydrolysis in shallow, nonturbid water.	> Slightly mobile in soil.	> Insecticide: Synthetic pyrethroid. > Induces long-lasting inhibition of the sodium ion channel activation gate, resulting in repetitive nerve signals in sensory organs, nerves, and muscles.	> Slightly toxic via acute oral and dermal routes. > Possible human carcinogen.	> Highly toxic to fish and aquatic invertebrates. > Practically nontoxic to birds. > Highly toxic to honey bees.
Permethrin	> n/a	> Hydrophobic with low water solubility. > Primary degradation pathways include photolysis and aerobic metabolism.	> Tends to partition to soil and sediment.	> Insecticide > Synthetic pyrethroid. > Induces long-lasting inhibition of the sodium ion channel activation gate, resulting in repetitive nerve signals in sensory organs, nerves, and muscles.	> Slightly toxic via acute oral and dermal routes. > Acute ingestion exposure causes nausea, vomiting, headache, dizziness, anorexia, and hypersalivation. > Possible endocrine-disruptor.	> Highly toxic to fish and aquatic invertebrates. > Practically nontoxic to birds.* > Highly toxic to honey bees. > Dermal exposure can cause life-threatening effects to cats.
Etofenprox	> n/a	> Virtually insoluble in water. > Stable to hydrolysis. > Susceptible to photolysis.	> Not likely to persist.	> Insecticide: Pyrethroid-like chemical. > Acts on ion channels of the insect nervous system.	> Low toxicity via acute oral, dermal, and inhalation routes.	> Highly toxic to fish and aquatic invertebrates.
Piperonyl butoxide (PBO)	> n/a	> Degrades by photolysis. > Moderately mobile in soil-water systems.	> Degrades rapidly in the environment by photolysis and metabolism by soil microbes. > Moderately mobile in soil-water systems.	> Synergist: added to insecticides. > Enhances the pesticidal properties of other active ingredients, such as pyrethrins and synthetic pyrethroids, by directly binding to microsomal enzymes in the target organism, thereby inhibiting the breakdown of the other pesticides.	> Low toxicity via acute oral, dermal, and inhalation routes. > Possible endocrine-disruptor.	> Moderately toxic to most fish, highly toxic to some fish. > Highly toxic to aquatic invertebrates.

[1] Toxicity levels (e.g., slight, low, moderate, high, etc.) are used prevalently in the published literature but are not standardized or representative of specific criteria. They qualitatively describe toxicity in relative terms.
n/a = not applicable

Table 4-1 Summary Characteristics of Active Ingredients

Active Ingredient: Chemical or Biological	Fate & Transport Air (Volatility)	Fate & Transport Water	Fate & Transport Soil	Mode of Action	Human Health[1]	Ecological Health[1]
Naled	> Readily degraded in air. > Can volatilize.	> Readily degraded in water. > Degrades by photolysis. > Low water solubility.	> Readily degraded in soil under aerobic and anaerobic conditions. > Most mobile in soil of low organic content such as sandy loam.	> Insecticide: Organophosphate for control of adult mosquitoes.	> Moderately toxic via acute oral, dermal, and inhalation routes. > Rapidly absorbed by oral and inhalation exposure and distributes quickly to all tissues.	> Moderately toxic to fish and aquatic invertebrates. > Lethal effects found for birds and honey bees.
Temephos	> n/a	> Breaks down via photolysis and microbial degradation. > Extremely hydrophobic with low solubility.	> Adsorbs rapidly to organic material in water and binds strongly to soils.	> Insecticide: Cholinesterase inhibitor for control of mosquito larvae.	> Moderately toxic via acute oral, dermal, and inhalation routes.	> Slightly to moderately toxic to fish. > Highly toxic to aquatic invertebrates. > Toxic to stoneflies and mayflies.
Bacillus sphaericus (Bs)	> n/a	> Dormant spores persist for several weeks or months. > The δ-endotoxins generally persist for 2 to 4-weeks but are degraded by sunlight and soil microbes.	> Does not percolate through the soil and readily binds to sediments when in water column.	> Mosquito larvicide. > Bacterium contains microscopic protein pro-toxins which paralyzes the gut of larvae when consumed, resulting in starvation.	> Not pathogenic and does not demonstrate any systemic toxicity.	> Not acutely toxic to birds, mammals, fish or invertebrates. > Mosquito predators not affected by secondary exposure.
Bacillus thuringiensis israelensis (Bti)	> n/a	> Degrade rapidly after exposure to UV light. > The δ-endotoxins are degraded by sunlight and soil microbes.	> Spores may persist in soil for several months.	> Mosquito larvicide. > Bacterium containing microscopic protein pro-toxins that paralyzes the gut.	> Not pathogenic and does not demonstrate any systemic toxicity.	> Not acutely toxic to birds, mammals, fish or invertebrates.
Spinosad	> Persists for a few hours in air.	> Persists for a few hours in water. > Binds readily to organic matter in water.	> Binds readily to organic matter in soil. Readily photo degrades. > Unlikely to leach to groundwater. > Quickly metabolized by soil microbes under aerobic conditions.	> Insecticide: Biologically derived from fermentation of a naturally occurring soil microbe. > Activates the CNS of insects through interaction with neuro-receptors causing continuous stimulation of the nervous system.	> Acute toxicity is low by all routes of exposure. > Not carcinogenic.	> Acute toxicity is low for fish, aquatic invertebrates, amphibians, and birds. > Very highly toxic to moths and butterflies.
Methoprene and s-Methoprene	> n/a	> Rapidly degrades in aqueous solution. > Degrades via photolysis and microbial metabolism.	> Relatively immobile in soil. > Metabolized in soil under aerobic and anaerobic conditions via photolysis and microbial metabolism.	> Insecticide: Long chain hydrocarbon ester. > Interferes with normal maturation process during insect life cycles, preventing reproduction.	> Very low toxicity via all acute routes.	> Moderately toxic to fish. > Very highly toxic to aquatic invertebrates. > Practically nontoxic to birds and amphibians.
Alcohol ethoxylated surfactant (monomolecular film)	> n/a	> Half-life in water is from 5 to 22 days.	> n/a	> Larvicide > Spread a thin film on the surface of the water that makes it difficult for larval pests to attach to the water surface, causing them to drown.	> n/a	> No observable effects to amphibians, fish, or non-target aquatic organisms (e.g., shrimp, snails, worms, mayfly naiad). > Surface-breathing insects may be temporarily impacted.
Aliphatic solvents (mineral oils, aliphatic hydrocarbons, petroleum distillates)	> Very low vapor pressure. > Low potential for volatility.	> Very low solubility. > Breakdown in 2 to 3 days.	> High sorption to organic matter.	> Larvicide > Creates a top-coating on water to drown larvae, pupae, and emerging adult mosquitoes.	> No deaths due to any acute doses.	> Practically nontoxic to fish, birds, and honey bees. > Rapid breakdown minimizes impact to non-target organisms.
Potassium Salts (soap salts)	> n/a	> n/a	> Degrade quickly by microbes and do not persist.	> Insecticide: > Fatty acids penetrate insect body coverings, disrupting cell membranes and causing dehydration and death.	> Low oral and dermal toxicity, but may cause stomach upset. > May be irritating to the skin and eyes.	> Slightly toxic to fish. > Highly toxic to aquatic invertebrates. > Practically nontoxic to birds.

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n/a = not applicable

Table 4-1 Summary Characteristics of Active Ingredients

Active Ingredient: Chemical or Biological	Fate & Transport Air (Volatility)	Fate & Transport Water	Fate & Transport Soil	Mode of Action	Human Health[1]	Ecological Health[1]
Chlorophacinone	> Volatizes slowly.	> Low water solubility. > Degrades slowly by acid hydrolysis.	> Degrades slowly by photo degradation. > Moderately persistent and immobile. > Major route of dissipation is aerobic metabolism.	> Rodenticide: > First-generation anticoagulant. Acts by blocking vitamin the K cycle, resulting in the inability to produce blood-clotting factors. Damages capillaries, causing diffuse internal hemorrhaging. Death occurs from hypovolemic shock or severe anemia.	> Highly toxic by all acute exposure routes.	> Toxic to wildlife and fish. > Toxic via primary and secondary ingestion routes.
Diphacinone	> n/a	> Low water solubility. > Stable to photolysis.	> Volatizes slowly from water to soil. > Susceptible to aerobic soil metabolism. > Binds tightly to soil.	> Rodenticide: > First-generation anticoagulant. Acts by blocking vitamin the K cycle, resulting in the inability to produce blood-clotting factors. Damages capillaries, causing diffuse internal hemorrhaging. Death occurs from hypovolemic shock or severe anemia.	> Highly toxic by all acute exposure routes.	> Slightly to moderately toxic to fish and aquatic invertebrates. Does not accumulate in fish > Slightly toxic to birds. > Possible secondary risk to avian predators and scavengers.
Brodifacoum	> Nonvolatile.	> Low water solubility. > Stable to hydrolysis.	> Relatively persistent. > Immobile in soil.	> Rodenticide: > Second-generation anticoagulant. Acts by blocking vitamin the K cycle, resulting in the inability to produce blood-clotting factors. Damages capillaries, causing diffuse internal hemorrhaging. Death occurs from hypovolemic shock or severe anemia.	> Highly toxic by all acute exposure routes.	> Very highly toxic to fish. > Toxic to birds via primary and secondary ingestion exposure. > Nontoxic to honey bees.
Bromadiolone	> n/a	> Stable to hydrolysis.	> Moderately persistent in soil. > Immobile in soil with high organic and clay content. > Susceptible to aerobic soil metabolism.	> Rodenticide > Second-generation anticoagulant. Acts by blocking vitamin the K cycle, resulting in the inability to produce blood-clotting factors. Damages capillaries, causing diffuse internal hemorrhaging. Death occurs from hypovolemic shock or severe anemia.	> Highly toxic by all acute exposure routes.	> Moderately toxic to fish. > Toxic to birds via primary and secondary ingestion exposure.
Difethialone	> n/a	> Adsorbs to suspended solids and sediments. > Can slowly volatize from water surfaces.	> Immobile in soil.	> Rodenticide > Second-generation anticoagulant. Acts by blocking vitamin the K cycle, resulting in the inability to produce blood-clotting factors. Damages capillaries, causing diffuse internal hemorrhaging. Death occurs from hypovolemic shock or severe anemia.	> Highly toxic by all acute exposure routes. > No genotoxic or carcinogenic effects have been noted.	> Highly toxic to fish and aquatic invertebrates. > Very likely toxic to most mammals. > Likely to adversely affect snakes, non-target rodents, carnivorous mammals. > Highly toxic to birds via primary and secondary routes.

[1] Toxicity levels (e.g., slight, low, moderate, high, etc.) are used prevalently in the published literature but are not standardized or representative of specific criteria. They qualitatively describe toxicity in relative terms.
n/a = not applicable

Table 4-1 Summary Characteristics of Active Ingredients

Active Ingredient: Chemical or Biological	Fate & Transport Air (Volatility)	Fate & Transport Water	Fate & Transport Soil	Mode of Action	Human Health[1]	Ecological Health[1]
Cholecalciferol (vitamin D)	> Expected to be nonvolatile.	> Essentially insoluble.	> Immobile in soil.	> Rodenticide > Ingestion results in hypercalcemia from mobilization of calcium from bone matrix to blood plasma leading to metastatic calcification of soft tissues.	> Toxic by all acute exposure routes.	> Considered of low hazard to avian and canine species. > May impact non-target rodents. > Not expected to bioconcentrate in mammals because it is metabolized.
Sulfur (fumigant)	> n/a	> n/a	> Elemental sulfur becomes incorporated into the natural sulfur cycle. Oxidizes into sulfate and reduces into sulfide. Mediated by microbes.	> Rodenticide > Fumigant. Ignited cartridges produce toxic gases, displacing oxygen in burrows, and causing asphyxiation.	> Low toxicity by acute exposure routes. > No known oncogenic, teratogenic, or reproductive effects.	> Practically nontoxic to fish and aquatic invertebrates. > Nontoxic to birds. > Nontoxic to bees.
Sodium Nitrate (fumigant)	> n/a	> n/a	> Sodium nitrates are naturally occurring substances.	> Rodenticide > Fumigant. Pyrolysis of cartridge products results in simple organic and inorganic compounds, such as nitrous oxide and carbon monoxide, which diffuse through burrows causing organisms to die of asphyxiation.	> Low acute oral toxicity. > May cause eye irritation and slight dermal irritation.	> Any non-target organism in the burrow at treatment time will likely be killed. > USEPA recommends that applicators observe signs around burrows carefully for presence of non-targets.
Imazapyr	> Nonvolatile.	> Degradation by photolysis. > Stable to hydrolysis. > Stable to aerobic and anaerobic aquatic metabolism.	> Persistent in soil. > Mobile in soil. > Stable to aerobic and anaerobic soil degradation. > Leaches to groundwater.	> Herbicide > Prevents the synthesis of branched-chain amino acids.	> Slightly toxic via acute oral, dermal, and inhalation routes. > No evidence of carcinogenicity or mutagenicity.	> Practically nontoxic to birds, fish, aquatic invertebrates, and honey bees. > Poses a risk to non-target vascular plants. > Not expected to bioaccumulate.
Glyphosate	> n/a	> Highly water soluble. > In aquatic systems, sediment appears to be the major sink for glyphosate residue. > Broken down by microbial degradation.	> Resistant to chemical degradation and sunlight and is fairly unleachable. > Relatively immobile in soil and does not move vertically below the six inch soil layer. > Low tendency to runoff. > Inactivated and biodegraded by microbes under aerobic and anaerobic conditions.	> Herbicide > Plants: Works via the shikimic pathway by inhibiting the enzyme EPSP synthase. Results in stunted growth, malformation, tissue death, etc. > Animals: Shikimic pathway absent in mammals.	> Very low toxicity via oral and dermal routes. > No evidence of carcinogenic or mutagenic effects. > Possible endocrine-disruptor.	> Practically nontoxic to birds, honey bees, fish, and freshwater invertebrates. > No evidence of bioaccumulation.

[1] Toxicity levels (e.g., slight, low, moderate, high, etc.) are used prevalently in the published literature but are not standardized or representative of specific criteria. They qualitatively describe toxicity in relative terms.
n/a = not applicable

Table 4-1 Summary Characteristics of Active Ingredients

Active Ingredient: Chemical or Biological	Fate & Transport Air (Volatility)	Fate & Transport Water	Fate & Transport Soil	Mode of Action	Human Health[1]	Ecological Health[1]
Triclopyr	> Nonvolatile.	> Highly soluble. > Primary loss via photodegradation. > Triclopyr triethylamine (TEA) rapidly dissociates in water to the acid/anion and triethanolamine. > Triclopyr butoxyethanol ester (TBEE) rapidly hydrolyses to the triclopyr acid/anion and butoxyethanol.	> Slightly mobile with sorption to soil increasing with time. > Primary loss via microbial degradation. > Moderately persistent, with persistence increasing with soil depth and anaerobic conditions.	> Herbicide > Pyridine-based synthetic auxin, which causes the plant to overdose on auxin resulting in epinasty, abnormal leaf formation, stem swelling, and death.	> (Technical triclopyr acid) Slightly toxic via acute oral, dermal, and inhalation routes. > (TEA and TBEE) slightly toxic by acute oral and dermal routes. Practically nontoxic by inhalation. > Not carcinogenic.	> (Triclopyr acid) Slightly toxic to birds and practically nontoxic to insects, fish, and aquatic invertebrates. > (TEA) Practically nontoxic to birds and invertebrates. Slightly toxic to fish. > (TBEE) Slightly toxic to birds, moderately to highly toxic to fish and invertebrates. > Does not bioaccumulate rapidly. > Triclopyr has low toxicity to grasses, but can injure conifers.
2,4-D (2,4-dichlorophenoxy acetic acid)	> n/a	> Found as a free anion in aqueous environments.	> Dissipation due to oxidative microbial mineralization, photodegradation, and leaching.	> Herbicide > Auxin-mimic. > Phenoxy or phenoxyacetic acid which acts as an herbicide, plant growth regulator, and fungicide.	> Low toxicity via oral and dermal routes. > Dose-dependent damage to eyes, thyroid, kidney, adrenals, ovaries, and testes have been observed in chronic studies of rats. > Possible endocrine disruptor.	> Slightly to moderately toxic to birds. > Some formulations highly toxic to fish. Bioconcentrates in fish. > Practically nontoxic to honey bees.
Sulfometuron methyl	> Low potential to volatilize.	> Hydrolysis, photolysis, and microbial degradation are major routes of transformation. > Low tendency to sorb to sediments.	> Hydrolysis, photolysis, and microbial degradation are major routes of transformation. > Potential to leach.	> Herbicide > Inhibits acetolactate synthase, which inhibits the production of amino acids required for cells growth. Retards shoot and root development.	> Low toxicity via oral, dermal, and inhalation routes.	> Nontoxic to birds, aquatic invertebrates, and bees. > Slightly toxic to fish. > Low potential to bioaccumulate. > Phytotoxic to duckweed and a broad range of terrestrial plants.
Bentazon	> n/a	> Photolysis, and microbial degradation are major routes of dissipation.	> Photolysis, microbial degradation, leaching, and runoff are major routes of dissipation. > Low binding affinity to soil.	> Herbicide: > On contact, bentazon interferes with the ability of plants to use sunlight for photosynthesis by inhibiting electron transport.	> Slightly toxic via oral, dermal, and inhalation routes.	> Slightly toxic to birds and small mammals. > Practically nontoxic to fish and aquatic invertebrates. > Low risk to aquatic plants.
Diuron	> n/a	> Major routes of dissipation are microbial degradation.	> Sorption highly correlated with soil organic matter. > Mobile and persistent. > Potential to leach to groundwater and contaminate surface waters.	> Herbicide > Substituted urea that inhibits photosynthesis by limiting the production of ATP, and other necessary metabolic processes. > One of the most commonly used herbicides in California.	> Low toxicity via oral, dermal, and inhalation routes. > Metabolism occurs through hydroxylation and dealkylation. > Known/likely carcinogen based on bladder cancer in rats.	> Slightly to practically nontoxic to birds. > Practically nontoxic to bees. > Moderately to highly toxic to fish and aquatic invertebrates. > Low bioaccumulation potential.
Benfluralin (benefin)	> Volatizes rapidly.	> Major routes of dissipation are photolysis and anaerobic metabolism.	> Low mobility and variable persistence.	> Herbicide > Inhibits growth by acting as a mitotic disruptor.	> Practically nontoxic by acute oral and dermal routes. > Possible endocrine disruptor.	> Practically nontoxic to birds, small mammals, and honey bees. > Highly toxic to fish and aquatic invertebrates. > Considered to be bioaccumulative.

[1] Toxicity levels (e.g., slight, low, moderate, high, etc.) are used prevalently in the published literature but are not standardized or representative of specific criteria. They qualitatively describe toxicity in relative terms.
n/a = not applicable

Table 4-1 Summary Characteristics of Active Ingredients

Active Ingredient: Chemical or Biological	Fate & Transport Air (Volatility)	Fate & Transport Water	Fate & Transport Soil	Mode of Action	Human Health[1]	Ecological Health[1]
Oryzalin	> n/a	> Primary degradation process is photolysis.	> Primary degradation process is photolysis. > Not mobile. > Anaerobic conditions in soil cause chemical reduction.	> Herbicide > Disrupts growth processes during germination by inhibiting cell division in plants.	> Practically nontoxic by acute oral route. > Moderately toxic by acute dermal and inhalation routes. > Possible human carcinogen.	> Slightly toxic to practically nontoxic to birds. > Moderately toxic to fish and freshwater invertebrates. > Practically nontoxic to honey bees. > Does not accumulate in fish.
DCPA (chlorthal dimethyl) [metabolite is tetrachloroterephthalic acid (TPA)]	> Volatilization from soil a major route of dissipation.	> Stable to hydrolysis and photolysis.	> Low persistence and mobility. > The DCPA metabolite TPA is unusually mobile and persistent and will leach to groundwater.	> Herbicide > Kills germinating seeds by disrupting microtubule formation in exposed cells, causing abnormal cell division.	> Slightly toxic to practically nontoxic by all acute exposure routes. > Possible human carcinogen. > Possible endocrine disruptor.	> Practically nontoxic to birds on an acute basis, but persistent enough to result in chronic exposure to birds. > Practically nontoxic to bees. > Slightly toxic to practically nontoxic to fish and aquatic invertebrates.
Dithiopyr	> Volatilization contributes more to dissipation than any other route.	> Degrades slowly in water. > Resistant to photolysis and hydrolysis.	> Immobile in soil.	> Herbicide	> Low acute toxicity. > No known mutagenic or carcinogenic effects.	> na
Metolachlor	> n/a	> Stable under hydrolysis.	> Degradation dependent on microbially-mediated and abiotic processes. Photolysis in soil. > Moderately persistent and mobile. Potential to leach to groundwater.	> Herbicide > Inhibits seedling development by acting as a growth inhibitor by suppressing synthesis of chlorophyll, proteins, fatty acids/lipids, isoprenoids, and flavonoids.	> Slightly toxic via acute routes. > Possible endocrine disruptor.	> Practically nontoxic to birds. > Moderately toxic to fish. > Slightly toxic to aquatic invertebrates. > Low potential for bioaccumulation.
Pendimethalin	> Volatilizes from soil.	stable to hydrolysis, but may be degraded by sunlight in aquatic systems	> Dissipates into the environment by binding to soil, microbially-mediated metabolism, and volatilization. > Persistence decreases with increased temperature and moisture and/or decreased soil organic carbon.	> Herbicide > Disrupts microtubules.	> Low acute toxicity. > Possible human carcinogen.	> Slightly toxic to birds. > Practically nontoxic to honey bees. > Highly toxic to fish and aquatic invertebrates. > High potential to bioaccumulate.
Alkylphenol ethoxylate (APE)	> n/a	> Degrades faster in water than in soil.	> Bind strongly to particulates and are persistent in sediments.* > Aerobic conditions facilitate biotransformation.	> Adjuvant: > Enhance activity of active ingredients in herbicides or offset any problems associated with spray application. > Toxicity of APEs to aquatic organisms increases with alkyl chain length.	> Nonylphenol is of low acute and dermal toxicity. > Possible estrogen-mimics.	> Nonylphenol is persistent in the environment, moderately bioaccumulative, and extremely toxic to aquatic organisms.
Polydimethylsiloxane Fluids	> Volatile.	> Insoluble.	> Typically sorb to particulate matter and become associated with soils and sediments. > Degradation is slow in moist soils and quick in dry soils.	> Adjuvant > Enhance activity of active ingredients in herbicides or offset any problems associated with spray application.	> n/a	> Appear to be relatively nontoxic to benthic invertebrates. > Exhibits little bioaccumulation potential.

[1] Toxicity levels (e.g., slight, low, moderate, high, etc.) are used prevalently in the published literature but are not standardized or representative of specific criteria. They qualitatively describe toxicity in relative terms.
n/a = not applicable

Table 4-1 Summary Characteristics of Active Ingredients

Active Ingredient: Chemical or Biological	Fate & Transport Air (Volatility)	Fate & Transport Water	Fate & Transport Soil	Mode of Action	Human Health[1]	Ecological Health[1]
Modified Plant Oils and Methylated Seed Oil	> n/a	> n/a	> n/a	> Adjuvant > Enhance activity of active ingredients in herbicides or offset any problems associated with spray application.	n/a	> Slightly toxic to fish (Competitor™). > Practically nontoxic to Daphnia (Competitor™). > Generally inert or essentially nonphytotoxic.
Lecithin	> n/a	> n/a	> n/a	> Adjuvant > Enhance activity of active ingredients in herbicides or offset any problems associated with spray application.	n/a	> Slightly toxic to fish (Liberate™). > Moderately toxic to Daphnia (Liberate™).

[1] Toxicity levels (e.g., slight, low, moderate, high, etc.) are used prevalently in the published literature but are not standardized or representative of specific criteria. They qualitatively describe toxicity in relative terms.
n/a = not applicable

4.1.1.1 Environmental Fate

The major routes of dissipation for pyrethrins in the environment are photolysis (both in water and soil, with half lives of less than 1 day in both cases) and to a lesser degree, aerobic soil metabolism (Table 4-2). Hydrolysis under alkaline conditions is an important route of dissipation for pyrethrins in water (half-life at pH 9 is 14-to 17 hours); however, this reaction appears to be relatively slow under neutral or acidic conditions, which are more likely to occur in the environment. Pyrethrins are likely to persist under anaerobic conditions. Pyrethrins quickly adsorb to suspended solids in the water column, and partition into the sediment. They adsorb strongly to soil surfaces and are generally considered immobile in soils; therefore, the potential to leach into groundwater is considered low (USEPA 2006f).

Table 4-2 Degradation of Pyrethrins

Degradation Method	Half-life	Reference
Hydrolysis, pH 9 (water)	14 to 17 Hours	USEPA 2006f
Hydrolysis, neutral or acidic	Slow	USEPA 2006f
Photolysis (water and soil)	<1 Day	USEPA 2006f
Volatilization (soil)	1.8 to 97 Days	Gunasekara 2005
Aerobic metabolism (soil)	10.5 Days	USEPA 2006f
Anaerobic metabolism (soil)	86.1 Days	USEPA 2006f

4.1.1.2 Human Toxicity

Pyrethrins have low to moderate acute toxicity via the oral, dermal, and inhalation routes (Category III and IV). They are a moderate eye irritant (Category III), a mild dermal irritant (Category IV), and not a skin sensitizer. The oral median lethal concentration (LD50) was found to be 1400 mg/kg in rats, the dermal LD50 was found to be greater than 2000 mg/kg in rabbits, and the inhalation LD50 was found to be 3.4 mg/L in rats (USEPA 2006f).

The critical toxicological effects of pyrethrins are (1) neurobehavioral effects (tremors, labored breathing, hyperactivity, secretory signs, matted coats), following acute, short-term, and chronic exposure, with nervous system lesions observed in the rat and mouse following acute exposure; (2) thyroid effects, following chronic exposure in the rat and dog; and (3) liver effects, following short- and long-term exposure in the rat, dog, and mouse. Following inhalation exposure, neurobehavioral effects were observed initially, and respiratory tract lesions were observed at all dose levels. The neurobehavioral effects and the mode of action on the sodium channel are considered relevant to humans because the effects are observed in both the rat and mouse, and the mode of action affects a basic function of the nervous system that is common to all animals (USEPA 2006f).

4.1.1.3 Ecological Toxicity

The results of the toxicity testing with the technical grade active ingredient suggest that pyrethrins are very highly toxic to freshwater fish (LC50 = 5.1 µg/L) and invertebrates (median effect concentration [EC50] = 11.6 µg/L), as well as to estuarine/marine fish (LC50 = 16.0 µg/L) and invertebrates (LC50 = 1.4 µg/L) on an acute basis. Chronic toxicity studies show that pyrethrins impair growth (length and weight) of freshwater fish (lowest observed adverse effect concentration [LOAEC] of 3.0 µg/L) and reproduction of freshwater invertebrates (LOAEC of 2.0 µg/L). The chronic no observed adverse effect concentrations (NOAECs) for freshwater fish and invertebrates were reported as 1.9 and 0.86 µg/L, respectively (USEPA 2006f).

Pyrethrins were practically nontoxic to avian species on an acute oral and dietary basis (oral LD50 >2,000 mg/kg bw; dietary LC50 >5,620 mg/kg diet) (USEPA 2006f).

SWRCB has evaluated freshwater aquatic life toxicity data from USEPA's Office of Pesticides' Ecotoxicity Database and has identified the lowest LC50 for pyrethrins as 1.4 µg/L. This value is based on toxicity to scuds and mysid shrimp during 96-hour tests (SWRCB 2012).

4.1.1.4 Ecological Toxicity Associated with ULV Application for Mosquito Abatement

The active ingredients used for control of adult mosquitoes have been deliberately selected for lack of persistence and minimal effects on non-target organisms when applied at label rates for ULV mosquito control. The products applied as ULV sprays for adult mosquito control are not formulated for persistence, because their purpose is to kill active adult mosquitoes in flight.

Three of the studies discussed below investigated aquatic toxicity following ULV applications of pyrethrins. One study using laboratory toxicity tests on samples after aerial application found no significant mortality to *Ceriodaphnia dubia* following aerial application, and inconclusive results for *Hyalella azteca* (sediment collected prior to application was toxic to *H. azteca*) (Weston et al. 2006). Another study found no significant mortality in caged mosquito larvae or mosquitofish after truck application, and no significant difference in macroinvertebrate abundance, biomass, or species diversity (Jensen et al. 1999). Another study (Lawler et al. 2008) used caged organisms (*Daphnia magna* and *Callibaetis californicus*) to evaluate toxicity after multiple applications, and found no significant difference in mortality.

Following aerial applications of Evergreen Crop Protection EC 60-6 (6 percent pyrethrins, 60 percent PBO) in Sacramento for West Nile virus, Larry Walker and Associates (2006) reported results of water testing on samples from 10 waterways within the treatment area. Treated areas were sprayed nightly for 3 days. One additional application occurred 9 days prior to the 3-day event at selected locations. Samples were taken immediately after application (within 1 to 6 hours), and the next day (16 to 23 hours after the application). Pyrethrins concentrations were detected between 0.234 and 3.77 µg/L from 9 of 26 samples collected immediately after the application. The average concentration for samples collected 1 to 6 hours after application was 0.270 µg/L. Pyrethrins were not detected (<0.2 µg/L) 16 to 23 hours after each spray event.

Testing was also carried out by Weston et al. (2006) following the same applications. Prior to aerial spraying, pyrethrins were not detected in water or sediment samples. Pyrethrins were not detected in water samples taken 10 to 34-hours after the spray applications; however, pyrethrins were detected in sediment samples after aerial spraying at concentrations ranging from 93.1 to 403 micrograms per kilogram [µg/kg] in 4-of 6 samples. Neither water nor sediment was tested at later intervals, so the duration of persistence could not be determined in this study. Laboratory tests were conducted to determine the effects of short-term chronic exposure of *Ceriodaphnia dubia* to water collected after the spray events, following USEPA protocol. No significant differences in mortality were observed. In addition, sediment toxicity tests were performed with the amphipod *Hyalella azteca,* and toxicity was observed in samples collected both before and after application. The authors concluded that pyrethrins should present little risk to aquatic organisms due to the low toxicity and lack of long-term persistence.

Water and soil deposition of pyrethrins following aerial applications was evaluated at two sites in California by Schleier et al. (2008). Water was sampled after aerial applications of pyrethrins and PBO in irrigation ditches at one site (Princeton) and in static ponds at another (Colusa). Pyrethrins were not detected following spray events at either site (the reporting limit was 0.5 µg/L or less). The authors concluded that the amounts of pyrethrins and PBO deposited on the ground and in water after aerial ULV insecticide applications are probably lower than those estimated by previously published studies to predict exposure and risk.

Deposition of pyrethrins following truck-mounted application was evaluated in large seasonal wetlands in California (Jensen et al. 1999). Pyrethrins were not detected (<20 µg/L) in surface waters one hour after ULV applications. The authors found no significant differences in macroinvertebrate abundance and

biomass or species diversity in areas treated with any of the materials when compared with untreated ponds. No mortality occurred in mosquitofish held in water (in sentinel cages in treated ponds). Similarly, no difference in mortality was observed for mosquito larvae held in water (in sentinel cages in treated ponds) when compared with untreated ones. The authors concluded that ULV applications for adult mosquito control were not likely to significantly affect aquatic insects or fish in these habitats.

Lawler et al. (2008) evaluated pyrethrins and PBO in sediment following multiple applications of pyrethrins from truck-mounted equipment in the Colusa and Sacramento National Wildlife Refuges in California. Stock tanks were filled with a layer of soil overlain with 1,150 liters of water. Zooplankton (*Daphnia magna*) were held in sentinel cages in the water column and mayfly larvae (*Callibaetis californicus*) were placed in cages at the bottom of each tank, where they were in contact with sediment. ULV applications of pyrethrins were made from truck-mounted equipment twice weekly for six weeks. Pyrethrins concentration in sediments and sentinel survival were evaluated after 5 and 11 spray event applications. Pyrethrins were found at low concentrations (23.1 and 33.1 µg/kg) in 2 of 6 tanks after five spray events, but there was no evidence of accumulation in sediments. After 11 spray events, sediment in 4 of 6 tanks (including one that had held residues after spray 5) contained no detectable amount of pyrethrins (<2 µg/kg), one tank had pyrethrins concentrations at 4 µg/kg, and another at 34.5 µg/kg. There was no significant difference in mortality for mayfly larvae held in sentinel cages on the sediment. Likewise, there was no significant difference in mortality seen in *D. magna* held in the water column. PBO-synergized pyrethrins had no detectable effect on the survival of *D. magna* held in tanks in the spray area, even after 11 biweekly spray events. They concluded that applications of pyrethrins and PBO at rates used for mosquito control did not have detectable effects on the indicator species.

Several papers were published documenting that ULV-applied mosquito adulticides do not accumulate in water or sediment during repeated applications. Chemical testing was conducted following multiple spray events by Amweg et al (2006). There was no increase in the level of pyrethrins or PBO following multiple daily spray events, and the concentration had returned to background level when samples taken one week after the last application were tested. Similarly, Lawler et al. (2008) reported that the concentration of pyrethrins and PBO in tanks within a treated area were not significantly higher after 11 applications than in samples taken after the fifth application. In many cases, the concentrations were actually lower following the 11th spray event than after the fifth spray event.

4.1.1.5 Summary of Toxicity and Potential Effects

Pyrethrins readily degrade in water and soil, but may persist under anoxic conditions. They tend to strongly adsorb to soil surfaces, and hence have low potential to leach into groundwater. These chemicals may have low to moderate acute toxicity to mammals; however, proper personal protective equipment would alleviate potential for human exposure, especially when delivered via ULV techniques. Pyrethrins may be highly toxic to fish (freshwater, estuarine, marine) and invertebrates, although, exposures would likely be low during and following ULV applications, which are designed to prevent environmental persistence and potential impacts to non-target ecological receptors.

Pyrethrin is used for both mosquito (five Districts) and yellow jacket wasp (three Districts) control. For yellow jacket wasp control, pyrethrin (1 percent of the formulation) was applied around parks, landscaping, and directly into ground nests. A single product was applied several hundred times throughout the reporting year at approximately one-ounce doses. For mosquito control, pyrethrin is applied to manmade and natural sites including ditches, and moving and standing water. Three products containing pyrethrin (5 percent) were applied several hundred times throughout the reporting year.

In addition to the toxicity values referenced in Sections 4.1.1.3 and 4.1.1.4, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the Districts.

4.1.2 Allethrins and *d-trans* allethrin

Allethrins are synthetic pyrethroids that are structurally very similar to cinerin I in naturally occurring pyrethrum. There are three asymmetric carbons and, thus, eight potential isomers; however, four isomers are present in the greatest concentration for product formulations. One of the stereoisomers, d trans of d isomer (d-trans allethrin), is recognized as being the most insecticidally active and toxicologically important of the four isomers. Allethrins are typically used as a "knock-down" agent and a different, residual pesticide is co-formulated with allethrins in the end-use products to kill the target pests (USEPA 2007e). D-trans allethrin is usually combined with synergists such as PBO.

Allethrins are used to control flying and crawling insects in a number of commercial, horticultural and residential applications. Commercial applications include space, broadcast and crack and crevice treatments in a variety of commercial, industrial, residential, and institutional sites. Horticultural applications include foliar and fogger treatment on nonfood plants. Residential uses include pest control in homes and outdoor domestic structures, on gardens, and direct application to pets. Allethrins are also approved for use in commercial animal premise (indoor) misting systems (USEPA 2007e).

4.1.2.1 Environmental Fate

Allethrins were the first pyrethroids developed and they differ from more recently developed pyrethroids in their high photolability (USEPA 2007e). The photolysis half-life is less than 8 hours (WHO 1989). Allethrins (and the d-trans allethrin component) are not soluble in water and are expected to adhere moderately to soil containing organic matter. When used in mosquito coils and mats, allethrins are released into the air where they will either be degraded by sunlight or be distributed in low concentrations to nearby surfaces.

4.1.2.2 Human Toxicity

The toxicity of allethrin varies with the amounts of different isomers present. The LD50 of allethrin in male rats is 1,100 mg/kg (685 mg/kg in female rats) while the LD50 of *d-trans* allethrin in rats is 860 mg/kg. Allethrin is slightly toxic to moderately toxic by dermal absorption and ingestion. The dermal LD50 of allethrin in rabbits is 11,332 mg/kg. Dermal exposure results in itching, burning, tingling, and numbness. Large doses by any route can cause physical symptoms such as nausea, vomiting, diarrhea, tremors, convulsions, and coma. A chronic dosage of 50 mg/kg/day for two years produced no detectable effect in dogs. Allethrin is not known to cause reproductive, teratogenic, mutagenic, or carcinogenic effects to mammals (EXTOXNET 1993a).

4.1.2.3 Ecological Toxicity

The chemical is practically nontoxic to birds but highly toxic to fish and invertebrates with the *d-trans* isomer exhibiting greater toxicity to non-target insects than allethrin (EXTOXNET 1993a). The LC50 for fish ranges from 0.0026 to 0.08 mg/L (USEPA 2007e). The bioaccumulation potential of allethrin is unknown.

4.1.2.4 Summary of Toxicity and Potential Effects

Allethrins readily degrade via photolysis especially when released into the air following coil deployment. Residual released material may deposit to soil surfaces and moderately adhere to organic matter. Allethrins may be highly toxic to fish, invertebrates, and non-target insects, but they are unstable in the environment and likely do not pose unacceptable risk to ecological receptors.

Allethrins, including *d-trans* allethrin are intermittently used to target yellow jacket wasp nests. Allethrin (*d-trans* isomer) is combined with another active ingredient, phenothrin in a single product used by two Districts for wasp and yellow jacket control. This product was used in 12 applications of 37.5 ounces (volume) (<0.1 ounces of active ingredients) during the summer of 2011 (of the reporting year). Because

allethrins are used in localized, low-volume applications, environmental persistence is not expected nor is unwanted exposure to non-target ecological or human receptors.

In addition to the toxicity values referenced in Sections 4.1.2.2 and 4.1.2.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the Districts.

4.1.3 Phenothrin (sumithrin or d-phenothrin)

Phenothrin has been registered by the EPA since 1976, and is used to control adult mosquitoes, and as an insecticide in transport vehicles such as aircraft, ships, railroad cars, and truck trailers. It is also used as an insecticide and miticide in commercial, industrial, and institutional nonfood areas, in homes and gardens, in greenhouses, and in pet quarters and on pets, and is used in urban areas, outdoor residential areas, around buildings and structures, at recreational areas, golf courses, zoos, and for agricultural crops (CDPR 2010a).

4.1.3.1 Environmental Fate

Phenothrin has a relatively high affinity for binding to soils, moderate persistence in surface soils, and low solubility. Its low leaching potential means that it is likely to remain immobile once it binds to soil sediments. The major routes of dissipation of phenothrin in the environment are photolysis in water (half-life at 6.5 days) and aerobic metabolism (in soil from 18.6 to 25.8 days, and in aquatic environments at 36.1 days) (Table 4-3). Even though phenothrin is likely to undergo photolysis in water, its high affinity for binding to particulate matter makes photolysis less likely to happen, except during the brief period in which the chemical is suspended in water before binding to sediment. Phenothrin is moderately persistent under aerobic conditions and is persistent under anaerobic conditions (USEPA 2008b).

Table 4-3 Degradation of Phenothrin

Degradation Method	Half-life	Reference
Hydrolysis, all pH levels	Stable	USEPA 2008b
Photolysis (water)	6.5 Days	USEPA 2008b
Aerobic metabolism (water)	36.1 Days	USEPA 2008b
Aerobic metabolism (soil)	18.6 to 25.8 Days	USEPA 2008b
Anaerobic metabolism (water)	173.3 Days	USEPA 2008b

4.1.3.2 Human Toxicity

Phenothrin is not known to be acutely toxic at high exposure levels to humans or mammals. Phenothrin exhibits low acute toxicity by oral (Category III), dermal (Category III), and inhalation (Category IV) routes of exposure. Phenothrin is a mild eye irritant (Category III) but is not a skin irritant or a skin sensitizer. The oral LD50 was found to be greater than 5,000 mg/kg in rats, the dermal LD50 was found to be greater than 2,000 mg/kg in rats and the inhalation LC50 was found to be greater than 2.1 mg/L in rats (USEPA 2008b).

Neurotoxic effects were observed in developmental toxicity studies but not observed in other acute, chronic, and subchronic toxicity studies done in rats and dogs up to the limit dose of 20,000 mg/kg/day. Maternal toxicity in rats was evidenced by the appearance of generalized clinical effects in dosed individuals; these effects included decreased maternal weight gain and decreased food consumption at the highest dosage tested of 3000 mg/kg/day (USEPA 2008b).

4.1.3.3 Ecological Toxicity

Phenothrin technical grade active ingredient is highly toxic on an acute basis, with the LC50 ranging from 15.8 to 18.3 µg/L for freshwater fish. Phenothrin is also highly toxic to estuarine/marine fish on an acute basis. The LC50 for estuarine and marine fish ranges from 38.3 to 94.2 µg/L. Phenothrin is very highly toxic to freshwater invertebrates. The EC50 for freshwater invertebrates is 4.4 µg/L. Chronic data for phenothrin show adverse reproductive effects for freshwater invertebrates at a NOAEC of 0.47 µg/L. This indicates a potential for chronic reproductive effects to freshwater invertebrates as a result of phenothrin exposure. Additional chronic effects to estuarine and marine invertebrates are expected based on the chronic reproductive toxicity to freshwater invertebrates and the acute effects to estuarine and marine invertebrates (USEPA 2008b).

Based on studies of avian acute dietary toxicity, phenothrin can be classified as practically nontoxic to avian species. The LC50 for avian dietary toxicity is above 5,000 parts per million (ppm) (USEPA 2008b).

SWRCB has evaluated freshwater aquatic life toxicity data from USEPA's Office of Pesticides' Ecotoxicity Database and has identified the lowest LC50 for phenothrin as 0.025 µg/L. This value is based on toxicity to mysid shrimp during a 96 hour test (SWRCB 2012).

4.1.3.4 Ecological Toxicity associated with ULV Application for Mosquito Abatement

Davis and Peterson (2008) measured family diversity, richness, and evenness at 1, 7, 14, and 28 days after truck application of phenothrin applied as Anvil 10+10 ULV. Most response variables showed no significant treatment effect, although there were some reductions in number of individuals. The authors concluded that the reductions in aquatic non-target populations did not suggest any trends or persistent deleterious biological effects following a single adulticide application.

New York City Department of Health sampled 32 locations for phenothrin and PBO before and after spray events during mosquito adulticide applications that occurred during July through September 2000. Out of the 68 post-application samples collected by the city, only two had concentrations of either phenothrin or PBO greater than the 0.5 µg/L reporting limit: 1.10 µg/L for phenothrin on August 18, 2000, at Mt. Loretto Pond on Staten Island; and 1.03 µg/L for PBO and 0.55 µg/L for phenothrin for a sample collected on August 5, 2000, at Alley Park Pond in Queens (Suffolk County 2006).

Zulkosky et al. (2005) evaluated phenothrin applied as Anvil. In 2002, phenothrin was not detected in either spray event (detection limit of 0.0005 µg/L). In 2003, phenothrin was detected at 0.0011 µg/L immediately after spray application, but was not detected in samples collected 1 to 10 days after spraying Anvil.

The Massachusetts Department of Agricultural Resources (2010) conducted a study where phenothrin was applied aerially as Anvil 10+10 ULV to six sites. There were no detections of phenothrin during this study (Massachusetts Department of Agricultural Resources 2010).

4.1.3.5 Summary of Toxicity and Potential Effects

Phenothrin is generally applied using ULV techniques, which encourages dissipation rather than persistence in the environment. It is not expected to pose unacceptable risk to human or ecological receptors, because it is handled in small amounts using proper personal protective equipment (by the applicator) and its low potential for exposure to non-targets.

As stated above, phenothrin and *d-trans* allethrins are used in conjunction for yellow jacket wasp control. One phenothrin product that contained *d-trans* allethrins was used in limited amounts by two districts during the reporting year. Phenothrins are used in localized, low-volume applications, therefore environmental persistence and meaningful exposure to non-target ecological receptors is not expected.

In addition to the toxicity values referenced in Sections 4.1.3.3 and 4.1.3.4, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British

Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.1.4 Prallethrin

Prallethrin is a synthetic pyrethroid with fast knock-down activity against household insect pests. It is used in household insecticide products against mosquitoes, houseflies, and cockroaches. Prallethrin also has veterinary uses in the treatment of domestic pets. Prallethrin has been applied in urban areas, outdoor residential areas, recreational areas, golf courses, around building and structures and at areas of standing water (CDPR 2010a). Prallethrin has an exciting effect on mosquitoes, and is added to Duet (the only prallethrin-containing adulticide product used in California) primarily for this property rather than its inherent toxicity. The other active ingredient in Duet is phenothrin.

4.1.4.1 Environmental Fate

Prallethrin readily sorbs to soils and sediments. The major route of dissipation of prallethrin in the environment is photolysis in both water (half-life at 13.6 hours) and soil (at 25 days) (Sumitomo Chemical 2009).

4.1.4.2 Human Toxicity

Prallethrin has low to moderate acute toxicity via the oral and dermal (Category II), and inhalation (Category IV) routes. It is a moderate eye irritant (Category III), not a dermal sensitizer, and is nonirritating to skin. The oral LD50 was found to be 460 to 640 mg/kg to rats, the dermal LD50 was found to be greater than 5000 mg/kg, and the inhalation LC50 (rats nose exposure) was found to be 288 to 333 mg/ml (USEPA 2003a) and 0.855 mg/L for males and 0.658 mg/L for females (MacBean 2012).

4.1.4.3 Ecological Toxicity

Prallethrin is highly toxic to fish (LC50 of 17.6 µg/L based on a 96 hour acute toxicity test to zebrafish (*Danio rerio*) and aquatic invertebrates (EC50 of 19 µg/L based on a 48 hour acute toxicity test to *Daphnia magna*). Prallethrin has low toxicity to algae (EC50 of 4.9 mg/L based on a 72 hour acute toxicity test to *Scenedesmus subspicatus*) and birds (LD50 of 1171 mg/kg for bobwhite quail). It is very toxic to bees (Agro-allianace Pty Ltd nd).

SWRCB has evaluated freshwater aquatic life toxicity data from USEPA's Office of Pesticides' Ecotoxicity Database and has identified the lowest LC50 for prallethrin as 3.9 µg/L. This value is based on toxicity to mysid shrimp during a 96 hour test (SWRCB 2012).

4.1.4.4 Summary of Toxicity and Potential Effects

Like other Type 1 pyrethroids, prallethrin is readily degraded via photolysis and is less environmentally persistent than the Type 2 variety. Prallethrin is used to treat domestic pets and is therefore, not expected to cause significant mammalian toxicity. Prallethrin is practically nontoxic to birds but is highly toxic to non-target organisms including, fish, aquatic invertebrates, and honey bees.

Prallethrin is intermittently used to target yellow jacket and paper wasp nests. Because this active ingredient is used in localized, low-volume applications, it is not expected to persist in the environment or pose unwanted toxicity to non-target ecological or human receptors.

In addition to the toxicity values referenced in Sections 4.1.4.2 and 4.1.4.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.1.5 Deltamethrin

Deltamethrin is a pyrethroid that kills insects on contact and through ingestion. Type II pyrethroids such as deltamethrin induce long-lasting inhibition of the sodium ion channel activation gate. This results in prolonged permeability of the nerve to sodium and produces a series of repetitive nerve signals in sensory organs, nerves, and muscles. The mechanism is the same for target and non-target organisms (National Pesticide Information Center 2010). The primary use of deltamethrin (approximately 85 percent of the total production) is for crop protection. Deltamethrin is also used to protect stored commodities such as cereals, grains, and coffee beans. Other uses include insect control for public health concerns, pest control in forestry, pest control in animal facilities, parasite control on animals, and as a wood preservative (CDPR 2000). Deltamethrin is used as a mosquito adulticide to a limited extent in California, but public health uses typically target other vectors such as yellow jackets. It is used as a barrier application and not a ULV application and it is not used over or adjacent to water bodies. Formulations used for mosquitoes include Suspend SC Insecticide (primarily used), and K-Othrine SC Insecticide, while Delta Dust, a powdered formulation, is used to control yellow jackets and wasps.

4.1.5.1 Environmental Fate

Deltamethrin degrades via hydrolysis, photolysis, and microbial action (Table 4-4) and is more persistent in soils with a high clay or organic matter content. The half-life of deltamethrin is approximately 25 to 33 days under aerobic conditions (CDPR 2000, FAO-WHO 2002a).

Table 4-4 Degradation of Deltamethrin

Degradation Method	Half-life	Reference
Hydrolysis, pH 8	31 Days	FAO-WHO 2002a
Hydrolysis, pH 9	2.5 Days	FAO-WHO 2002a
Photolysis (water)	<21 Days	FAO-WHO 2002a
Photolysis (soil)	48 Days	FAO-WHO 2002a
Aerobic metabolism (soil)	25 to 33 Days	FAO-WHO 2002a
Anaerobic metabolism (soil)	32 to 36 Days	FAO-WHO 2002a
Field conditions (soil)	14 to <150 Days	FAO-WHO 2002a

4.1.5.2 Human Toxicity

Deltamethrin is of low to moderate acute toxicity. The oral LD50 for rats is 30 mg/kg in an oil vehicle or >5,000 mg/kg in a water vehicle. The LD50 for dogs is 300 mg/kg (MacBean 2012). The acute dermal LD50 for rabbits is >2,000 mg/kg and no skin irritation and slight eye irritation were reported (EXTOXNET 1995a). Symptoms of acute exposure in humans include ataxia, convulsions, dermatitis, edema, diarrhea, headache, irritability, among others (EXTOXNET 1995a). Symptoms of chronic exposure of humans to deltamethrin include choreoathetosis, hypotension, prenatal damage, and shock (EXTOXNET 1995a). Deltamethrin has no reported teratogenic, mutagenic, or carcinogenic effects. Mice fed doses of deltamethrin during gestation showed no changes in the number of implants, fetal mortality, fetal weight, or malformations (EXTOXNET 1995a).

4.1.5.3 Ecological Toxicity

Deltamethrin is very highly toxic to fish and aquatic invertebrates. It is practically nontoxic to birds (USEPA 2010a). Of particular importance when using pyrethroids in general is to note that non-target insects may have the same approximate sensitivity as mosquito larvae (Mian and Mulla 1992). These include mayflies, stoneflies, whirligig beetle, caddisflies, and the snipefly. The water boatman and

backswimmer have low sensitivity to some pyrethroids. See Table 2 of Mian and Mulla (1992). Deltamethrin is very highly toxic to honey bees (USEPA 2010a).

4.1.5.4 Summary of Toxicity and Potential Effects

Deltamethrin may be persistent in high organic matter soils and aquatic sediments. It is nonselective and therefore, may pose risk to non-target organisms such as honey bees. Deltamethrin is highly toxic to fish (and bioaccumulative) and invertebrates, however, it is generally not applied to aquatic systems. It is not expected to pose risk to aquatic receptors under the prescribed application usage by the nine Districts.

One product containing deltamethrin (0.05 percent) is used by two Districts for yellow jacket wasp control. It is primarily used in the summer months to specifically target yellow jacket wasp ground nests. It was applied almost 300 times during the summer of 2011. There are a range of limited exposure and localized and limited usage patterns and potential unwanted effects are dependent on the use.

In addition to the toxicity values referenced in Sections 4.1.5.2 and 4.1.5.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.1.6 Esfenvalerate

Esfenvalerate is a broad-spectrum nonselective insecticide applied as needed for the control of a wide selection of arthropod pests. Esfenvalerate is a mixture of four stereoisomers, enriched with the S,S-isomer, the most insecticidally active isomer. (The parent mixture, fenvalerate, is a mixture of the same four isomers in relatively equal proportions.) Esfenvalerate containing products registered for use in California are applied for home/garden consumer use, commercial pesticide application use, and agricultural production use (Kelley 2003). Esfenvalerate is a voltage-dependent sodium-channel agonist. Esfenvalerate works against the insect nervous system, resulting in repetitive firing of neurons.

4.1.6.1 Environmental Fate

Esfenvalerate is practically insoluble in water, extremely hydrophobic and has a strong tendency to bind to soil particles. Esfenvalerate, as a result of these characteristics, is relatively immobile in soil and shows a low tendency to leach. Esfenvalerate, when present in surface waters, is expected to be bound to suspended particulates (clay, soil, and sediment particles) and to organic matter (Kelley 2003). Primary degradation pathways include photolysis and aerobic metabolism (Table 4-5). (FAO-WHO 2002b)

Table 4-5 Degradation of Esfenvalerate

Degradation Method	Half-life	Reference
Hydrolysis, pH 5–9	64 to 130 Days	FAO-WHO 2002b, Kelley 2003
Photolysis (water)	6 to 17.2 Days	FAO-WHO 2002b, Kelley 2003
Photolysis (soil)	3 to 15.8 Days	FAO-WHO 2002b, Kelley 2003
Aerobic metabolism (water)	4 to 72.3 Days	Kelley 2003
Aerobic metabolism (soil)	35 to 546 Days	FAO-WHO 2002b, Kelley 2003
Anaerobic metabolism (water)	65 to 79 Days	Kelley 2003
Anaerobic metabolism (soil)	104 to 203 Days	Kelley 2003

4.1.6.2 Human Toxicity

Esfenvalerate is relatively new compared to other pesticides on the market; therefore, the usage history for this compound is incomplete. The oral LD50 of esfenvalerate in rats is 75 to 88 mg/kg (Table 6-1). The dermal LD50 in rabbits is 2,000 mg/kg (considered moderately toxic) (Table 6-1). The inhalation LC50 in rats is greater than 2.93 mg/L (EXTOXNET 1994, (Table 6-1). Esfenvalerate has not been implicated in cancer or birth defects in mammal studies. Esfenvalerate is included in the final list of candidate chemicals for screening under the USEPA Endocrine Disruptor Screening Program (USEPA 2009a).

4.1.6.3 Ecological Toxicity

Esfenvalerate is moderately toxic to birds. The acute oral LD50 for mallard ducks is 9,932 mg/kg. The compound is highly toxic to fish and aquatic invertebrates. Esfenvalerate is highly toxic to bees (EXTOXNET 1994) (Table 6-1). The compound tends to repel bees for a day or two after application. Most intoxicated bees die in the field before they can return to the hive (EXTOXNET 1994). The 96-hr LC50 is 0.00026 mg/L for bluegill and rainbow trout and 0.00024 µg/L for *Daphnia magna* (EXTOXNET 1994). Esfenvalerate rapidly bioaccumulates in fish. The bioaccumulation factor in rainbow trout is about 400 times the background esfenvalerate water concentrations.

4.1.6.4 Summary of Toxicity and Potential Effects

Esfenvalerate is insoluble in water and tends to bind to organic matter in soils and sediment with low leaching potential. Degradation occurs through photolysis and aerobic metabolism, therefore it does not appear to persist in the environment. This pesticide is generally deployed in bait stations above the ground, which limits its release to the soil surface and aquatic systems. Esfenvalerate is considered moderately toxic to mammals and birds; and highly toxic to aquatic invertebrates and honey bees. In addition, it is both highly toxic to and bioaccumulative in fish.

Esfenvalerate was not used by the MVCAC districts during the reporting year. As a result, potential loading scenarios to different habitats types could not be determined. Potential non-target biological receptors could also not be surmised due to the lack of habitat-specific application data. However, as noted above, honey bees could be at risk from this pesticide. There pesticide also demonstrates a lack of persistence potential.

In addition to the toxicity values referenced in Sections 4.1.6.2 and 4.1.6.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.1.7 Lambda-cyhalothrin

Lambda-cyhalothrin is a synthetic pyrethroid insecticide used for controlling pest insects in agriculture, public health, and in construction and households. Lambda-cyhalothrin is a 1:1 mixture of two of the four enantiomers, which constitute cyhalothrin. Insecticidal products containing lambda-cyhalothrin have been widely used to control insect pests in agriculture, public health, and homes and gardens (He et al. 2008).

4.1.7.1 Environmental Fate

Lambda-cyhalothrin is an extremely hydrophobic compound and has rapid and strong adsorption to soils and sediments. Lambda-cyhalothrin residues dissolved in water decrease rapidly if suspended solids and/or organic materials are present because lambda-cyhalothrin molecules are strongly adsorbed by particulates and plants (He et al. 2008). Primary degradation pathways include photolysis and aerobic metabolism (Table 4-6). (FAO-WHO 2008)

Table 4-6 Degradation of Lambda-cyhalothrin

Degradation Method	Half-life	Reference
Hydrolysis, pH 5	Stable	FAO-WHO 2008
Hydrolysis, pH 7	454 to Days	FAO-WHO 2008
Hydrolysis, pH 9	7.3 Days	FAO-WHO 2008
Photolysis	24 Days	FAO-WHO 2008
Aerobic metabolism (soil)	22 to 83 Days	FAO-WHO 2008
Microcosm (water)	<1 Day	He, et al. 2008

4.1.7.2 General Toxicity

In 2005, a pyrethroid insecticide analysis report was completed for the Sacramento, San Joaquin, and Central valleys to summarize existing information on pyrethroid usage patterns, fate and transport, and toxicity (Oros and Werner 2005). The report identified lambda-cyhalothrin as one of the top five pyrethroids used in these areas to manage pests in a variety of settings and applications. According to Oros and Werner (2005), lambda-cyhalothrin has been found in sediments at levels that are known to be toxic to the several representative invertebrate species in the Sacramento, San Joaquin, and Central valleys.

4.1.7.3 Human Toxicity

Lambda-cyhalothrin is moderately toxic via the acute oral, dermal, and inhalation routes (NPIC 2001).The median lethal oral dose (LD50) of lambda-cyhalothrin has been reported at 56 to 79 mg/kg for female and male rats (MacBean 2012), respectively or as high as 144-mg/kg (Ray 1991) (Table 6-1). Technical-grade lambda-cyhalothrin is less toxic when exposure occurs dermally, given its relatively poor absorption by this route; dermal LD50s of 632 mg/kg and 696 mg/kg for male and female rats have been cited (Table 6-1). One of the formulated products, Karate®, can cause significant skin and eye irritation (Ray 1991).

Acute exposure to lambda-cyhalothrin has been linked with changes in neurological function when administered at a single dose of 0, 2.5, 10, or 35 mg/kg-d, a result consistent with its action on sodium channel permeability (USEPA 2002). Rats exposed for 4-hours to an aerosol of cyhalothrin at concentrations of 3.68 to 68 mg/m^3 exhibited a concentration-dependent increase in signs of neurotoxicity. Effects ranged from lethargy and salivation at the lowest concentration, to death (shortly after termination of exposure) at the highest concentration (Curry and Bennet 1985).

Chronic studies of lambda-cyhalothrin and cyhalothrin have repeatedly and consistently documented decreased body weight gain and reduced food consumption exposure levels as low as 0.9 mg/kg/day, with numerous study results yielding NOAELs of 1 to 2.5 mg/kg/day. Signs of neurotoxicity and changes in organ weights are also common effects of chronic exposure to lambda-cyhalothrin and cyhalothrin (USEPA 2002, 2004a, 2007a,b).

Although little research on the developmental toxicity of lambda-cyhalothrin is publically available, the information provided by the USEPA indicates that the maternal NOAEL was 10 mg/kg-d for both species (USEPA 2002, 2004a). The developmental NOAEL was the highest dose tested in each study; in rats, it was 15 mg/kg-d, and in rabbits, 30 mg/kg-d. A study of the reproductive effects of this compound over three generations indicated a LOAEL of 5.0 mg/kg-d which elicited adverse effects in both the parents and pups, with toxicity manifested as reduced body weight and body weight gain in the parents, and reduced pup weight and reduced pup weight gain during lactation (USEPA 2002, 2004a). No genotoxicity data for cyhalothrin or lambda-cyhalothrin were identified in recent USEPA pesticide tolerance documents

(USEPA 2002, 2004a, 2007b). A chronic feeding study of cyhalothrin in the diets of rats resulted in no oncogenic effects (USEPA 2002).

4.1.7.4 Ecological Toxicity

Lambda-cyhalothrin is of low toxicity to birds. The oral LD50 for the mallard duck is >3,950 mg/kg and the dietary LC50 for the bobwhite quail is 5,300 mg/kg (WHO 2007, MacBean 2012). A 1-year neurotoxicity study on the dog where lambda-cyhalothrin was administered by gavage, derived a NOAEL of 0.5 mg/kg bw per day and a LOAEL of 3.5 mg/kg bw per/day. Systemic neurotoxicity (i.e., ataxia, tremors, and occasionally convulsions) was observed, with an overall NOAEL of 0.5 mg/kg bw per day. Signs of systemic neurotoxicity were observed from the first week and generally occurred within a few hours after treatment (PMRA 2003). In 2007, the USEPA released a revised Pesticide Tolerance for lambda-cyhalothrin, published in the Federal Register Volume 72, Number 157, indicating that the dog is known as the most vulnerable to toxic effects.

Lambda-cyhalothrin is highly toxic to aquatic organisms, including fish, shellfish, shrimp, crabs and clams (He et al. 2008). The 96-hr LC50 is 0.21 µg/L for bluegill (WHO 2007) and 0.24 µg/L for rainbow trout (He et al. 2008). The 48-hr LC50 for *Daphnia magna* is 0.26 µg/L (MacBean 2012).

Lambda-cyhalothrin is known to be toxic to honey bees. As presented by IPCS, honey bees have an oral LD50 of 0.97 µg/bee. Additionally, He et al. (2008) and MacBean 2012 reported an oral LD50 over 48-hours and contact LD50 of 0.038 µg/bee and 0.909 µg/bee, respectively.

4.1.7.5 Summary of Toxicity and Potential Effects

Lambda-cyhalothrin may be persistent in the absence of light and has been found at concentrations known to be toxic to aquatic invertebrates. The potential for persistence of this chemical and its toxicity to mammals, aquatic organisms (vertebrates and invertebrates), and non-target insects such as honey bees is of concern from a potential human and ecological risk perspective.

Lambda-cyhalothrin is available to the public in commonly-used products for residential wasp control. Lambda-cyhalothrin is used by one district for targeted application to yellow jacket and paper wasp nests. This product (0.01 percent lambda-cyhalothrin) is used throughout the year and exceeded 2,000 ounces (volume) of product and less than one ounce of active ingredient during the reporting year. Some of the Districts use products containing this active ingredient as a courtesy to the public to assist with wasp control at residences (restricted to yards, gardens, and home exteriors). The amount applied directly to wasp nests (by the public and the Districts) is minute and there is little to no potential for non-target organism exposures. The potential for human exposure (public and trained professionals [e.g., District staff]) is extremely low when product label instructions are properly followed.

Although there is a potential for environmental persistence and exposure to domestic pets and non-target receptors, this a.i. is readily available as an insect spray and the uses by the Districts are generally focused, and very localized to minimize or eliminate those exposures.

In addition to the toxicity values referenced in Sections 4.1.7.3 and 4.1.7.4, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.1.8 Resmethrin

Resmethrin has been registered by the EPA since 1967, and is used to control flying and crawling insects in the home, lawn, garden, and industrial sites. It can also be used to control insects on ornamental plants (outdoor and greenhouse use), on pets and horses, and as a mosquitocide. Resmethrin is also used at commercial and industrial areas, warehouses, urban areas, and golf courses, and on aquatic areas or standing water, and selected agricultural crops. Because of its toxicity to fish, resmethrin is a restricted-

use pesticide (RUP) for the purpose of public health mosquito abatement, and is available for this use only by certified pesticide applicators or persons under their direct supervision. Resmethrin works by interacting with sodium channels in the peripheral and central nervous system of target organisms (USEPA 2006g).

4.1.8.1 Environmental Fate

Resmethrin degrades rapidly when exposed to light; however, when not subject to photolysis, resmethrin tends to be environmentally persistent (Table 4-7). Reported half-lives in water range from 22 minutes (photolysis in seawater) to 37 days (aerobic metabolism). Resmethrin has low mobility and has a high affinity to bind to soils/sediments and organic carbon (USEPA 2006g).

Table 4-7 Degradation of Resmethrin

Degradation Method	Half-life	Reference
Hydrolysis, pH 5 – 9	>89 Days	USEPA 2006g
Photolysis (distilled water)	47 minutes	USEPA 2006g
Photolysis (seawater)	22 minutes	USEPA 2006g
Aerobic metabolism (water)	37 Days	USEPA 2006g
Aerobic metabolism (soil)	198 Days	USEPA 2006g
Anaerobic metabolism (soil)	Stable	USEPA 2006g

4.1.8.2 Human Toxicity

Resmethrin has low acute toxicity via the oral (Category III), dermal (Category III), and inhalation (Category IV) routes of exposure. It is not an eye or skin irritant nor is it a skin sensitizer. The oral LD50 was 4639 to 6091 mg/kg in rats, the dermal LD50 was found to be greater than 2000 mg/kg in rabbits, and the inhalation LC50 was found to be 5.28 mg/L in rats (USEPA 2006g). Lower oral LD50 and inhalation LC50 values have been reported by MacBean (2012) and have been used in Table 6-1. Resmethrin is included in the final list of chemicals for screening under the USEPA Endocrine Disruptor Screening Program (USEPA 2009a).

4.1.8.3 Ecological Toxicity

Resmethrin is moderately toxic to birds. The oral LD50 for red-winged blackbirds is 75 mg/kg. Resmethrin technical grade active ingredient is very highly toxic to freshwater fish and invertebrates and to estuarine/marine fish and invertebrates. The LC50 or EC50 ranges from 0.28 to 1.3 µg/L for rainbow trout (*Oncorhynchus mykiss*), water flea (*Daphnia magna*), sheepshead minnow (*Cyprinodon variegatus*), and pink shrimp (*Penaeus duorarum*). Both freshwater fish and estuarine/marine fish early life-stage chronic toxicity tests were used to evaluate the chronic toxicity of resmethrin. Results from the freshwater fish early life-stage toxicity test indicated a NOAEC of 0.32 µg/L and an LOAEC of 0.59 µg/L (EPA 2006g). Resmethrin is very highly toxic to honey bees (LD50 = 0.063 µg/bee) (USEPA 2006g).

SWRCB has evaluated aquatic life toxicity data from USEPA's Office of Pesticides' Ecotoxicity Database and has identified the lowest LC50 for resmethrin of 0.28 µg/L (SWRCB 2012). This value is based on toxicity to rainbow trout during a 96-hour test.

4.1.8.4 Ecological Toxicity associated with ULV Application for Mosquito Abatement

Abbene et al. (2005) evaluated deposition of resmethrin in formulation with PBO (Scourge) following truck-mounted applications in fresh and salt water marshes at 6 sites. Resmethrin was not detected in water samples from any site (<0.005 µg/L). Deposition of resmethrin following aerial applications by helicopter was assessed in the same report (Abbene et al. 2005). Applied materials were detected in

some water samples taken within 30 minutes of the application. The average concentration of resmethrin following helicopter applications was 0.037 µg/L. The highest concentrations were found in some samples collected from surface water within 1 hour of helicopter applications (0.293 µg/L resmethrin). The authors carried out a series of sample collections after two spray events to evaluate the persistence of the material in water. Resmethrin displayed an exponential decrease and was not detected (<0.005 µg/L) within 9 hours of the application. One site included two repeat weekly applications of resmethrin following an application of methoprene the prior week. Concentrations of resmethrin and PBO measured after the second application were lower than those measured after the first application.

The same study included effects of aerial applications of resmethrin and PBO on two aquatic organisms: the sheepshead minnow (*Cyprinodon variegatus*) and the estuarine grass shrimp (*Palaemonetes pugio*) (Suffolk County 2006). The field study faced problems with low dissolved oxygen and high temperature, which compromised their ability to detect toxicity that may have been due to pesticide exposure. Therefore, dosing experiments and prey capture tests were conducted in the laboratory to measure toxicity of the applied products. These tests demonstrated that the doses used in the spray were not directly toxic to grass shrimp and did not affect their ability to capture prey under controlled conditions. Further laboratory experiments demonstrated that all of the mortality seen in the field could have been caused by low dissolved oxygen alone, using a USEPA time-to-death approach. Furthermore, their data showed that the chemicals used had very low persistence in the water column, as discussed above. Resmethrin was never detected in sediment and was not detected in samples from surface water taken more than 2 hours after the spray.

A related study evaluated benthic community structure, and found that benthic population differences could not be attributed to the application of pesticides, but were more likely due to environmental differences (Suffolk County 2006).

Zulkosky et al. (2005) sampled freshwater ponds, salt marshes, tidal inlets and embayments, and marine coastal water off Staten Island, New York within an hour after mosquito control applications of resmethrin (Scourge). In 2002, resmethrin was detected in five of ten locations at concentrations ranging from 0.0017 to 0.98 µg/L (detection limit of 0.0005 µg/L). No information was provided on application methods at each site.

4.1.8.5 Summary of Toxicity and Potential Effects

Resmethrin may also be persistent in environments free of light (e.g., bound to organic matter in anoxic soils and sediments). Due the potential for persistence and high toxicity to both aquatic and estuarine/marine fish and invertebrates, as well as the potential for endocrine disruption, this RUP may be of concern from a potential ecological risk perspective.

Resmethrin is contained in one product (18.5 percent) used by one of the Districts. It is applied to habitats with tree holes, residential areas near reclaimed marshes, and industrial areas for mosquito control. Seven applications during the spring and summer (2012 and 2011, respectively) resulted in the use of almost two gallons of product (<0.5 gallons of resmethrin). Studies have shown rapid dissipation/low persistence and no observed aquatic fish and invertebrate toxicity following aerial ULV applications.

Scourge® is being phased out and replaced with a nonresmethrin alternative, making this product less problematic.

In addition to the toxicity values referenced in Sections 4.1.8.2 and 4.1.8.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.1.9 Tetramethrin

Tetramethrin is part of the pyrethroid class of pesticides and was first registered in 1968. It is a broad spectrum, nonsystemic, synthetic pyrethroid used to control flying and crawling insects in a number of

commercial, horticultural and residential applications. Commercial applications include space, broadcast and crack-and-crevice treatment in a variety of commercial, industrial, residential, and institutional sites. Horticultural applications include foliar and fogger treatment on nonfood plants. Residential uses include pest control in homes and outdoor domestic structures, on gardens and direct application to cats, dogs and horses. Tetramethrin is a mixture of four stereoisomers designated as 1R-trans, 1R-cis, 1S-trans, and 1S-cis in an approximate ratio of 4:1:4:1. The first two isomers are the most insecticidally active (USEPA 2010c).

4.1.9.1 Environmental Fate

Tetramethrin is not a persistent pyrethroid in the environment (Table 4-8). It may be co-formulated with synergists, other active ingredients such as pyrethrins and pyrethroids, and growth inhibitors. These other ingredients are more persistent than tetramethrin and provide residual activity against insects not initially exposed. Tetramethrin decomposes rapidly by photolysis and hydrolysis in shallow, nonturbid water. Tetramethrin is slightly mobile in soil (USEPA 2010c).

Table 4-8 Degradation of Tetramethrin

Degradation Method	Half-life	Reference
Hydrolysis, pH 5	15.9 to 19.7 Days	USEPA 2010c
Hydrolysis, pH 7	0.89 to 1.06 Days	USEPA 2010c
Hydrolysis, pH 9	13 to 20 minutes	USEPA 2010c
Photolysis (air)	30 minutes	USEPA 2010c

4.1.9.2 Human Toxicity

The USEPA considers tetramethrin to be slightly toxic via the oral and dermal routes (Category IV and III respectively) and classifies it as a Category III eye irritant. The oral LD50 for rats is >5,000 mg/kg. The dermal LD50 for rabbits is >2,000 mg/kg. Tetramethrin meets the criteria for classification as a possible human carcinogen (USEPA 2010c) (Table 6-1).

4.1.9.3 Ecological Toxicity

The USEPA evaluated the potential ecological risk posed by use of tetramethrin both indoors and outdoors and concluded that exposure to non-target organisms is unlikely. Tetramethrin is considered practically nontoxic to birds and terrestrial mammals. The oral LD50 for bobwhite quail is >2,250 mg/kg bw (USEPA 2010c). Tetramethrin is considered highly toxic to aquatic organisms. The 96-hr LC50 of tetramethrin for rainbow trout is 3.7 µg/L. The 48-hr EC50 for immobilization of *Daphnia magna* is 45 µg/L (USEPA 2010c). Tetramethrin is also highly toxic to honey bees. The contact 48-hr LD50 is 0.155 µg/bee (Table 6-1).

4.1.9.4 Summary of Toxicity and Potential Effects

Tetramethrin is not persistent in the environment and degrades rapidly (photolysis and hydrolysis) in surface waters. It is only slightly mobile in saturated soils and is highly toxic to fish and aquatic invertebrates, as well as honeybees. Tetramethrin does not appear to pose a risk to humans; however, it has been classified as a possible human carcinogen.

Tetramethrin is used by one district during the spring, summer, and fall for yellow jacket and paper wasp control. A single product (containing 0.1 percent tetramethrin) was applied directly to more than 80 nests, which corresponded to approximately 2,000 ounces (volume) of product, or approximately 2 ounces of active ingredient used during the reporting year. Although there is a potential for effects to fish and

aquatic invertebrates, the uses by the Districts are generally focused, and very localized to minimize or eliminate those potential non-target exposures.

In addition to the toxicity values referenced in Sections 4.1.9.2 and 4.1.9.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.1.10 Permethrin

Permethrin is a Type I pyrethroid (i.e., it lacks a cyano group at the alpha-carbon position of the alcohol moiety) that primarily targets the nervous system of insects, causing muscle spasms, paralysis, and death (USEPA 2006d). Permethrin has been registered by the EPA since 1979, and is currently registered and sold in a number of products such as household insect foggers and sprays, tick and flea sprays for yards, flea dips and sprays for cats and dogs, termite treatments, agricultural and livestock products, and mosquito abatement products. Permethrin is also used at urban areas, household gardens, recreation areas, golf courses, hospitals, zoos, pastureland, and animal husbandry areas (CDPR 2010a).

4.1.10.1 Environmental Fate

Permethrin has very low mobility, is moderately persistent and has a high affinity to bind to soils/sediments and organic carbon. The relatively low water solubility and hydrophobic nature of permethrin leads to strong soil adsorption and a tendency to partition to sediment in aquatic systems. It is also slow to hydrolyze and biodegrade. Reported half-lives in surface water range from 1.8 hours to <2.5 days (Imgrund 2003). Major degradation pathways include photolysis and microbial metabolism (Table 4-9).

Table 4-9 Degradation of Permethrin

Degradation Method	Half-life	Reference
Hydrolysis	Stable (pH 3-6), 125–350 Days (pH 9)	CDPR 2010a, USEPA 2009a
Photolysis, ponds (water)	19.6 to 27.1 Hours	Imgrund 2003
Photolysis (soil)	104 to 324-Days	Imgrund 2003
Aerobic metabolism (soil)	3.5 to 113 Days	Imgrund 2003
Anaerobic metabolism (water)	113 to 175 Days	USEPA 2009a
Anaerobic metabolism (soil)	<3 to 197 Days	Imgrund 2003
Sediment/seawater degradation	<2.5 Days	Imgrund 2003
Streams, pH 7.0 to 7.5, 13 to 15°C	1.8 to 20.4 Hours	Imgrund 2003

4.1.10.2 Human Toxicity

Acute oral studies conducted with rats by the Department of Defense (DOD 1977) showed that exposure to permethrin caused tremors, weight loss, and increased liver and kidney weights starting at 185 mg/kg. The NOAELs in the DOD studies ranged from 92 to 210 mg/kg.

Oral LD50 values in rats range from 220 mg/kg to 8900 mg/kg and in mice, from 230 mg/kg to 1,700 mg/kg (IPCS 1999). The lethal dose of permethrin depended both on the vehicle in which permethrin was administered, as well as the cis/trans composition of the mixture. Permethrin is only slightly toxic via the dermal route, with an LD50 >2,000 mg/kg in rabbits (Braun and Killeen 1975b, Sauer 1980a). Permethrin of various cis/trans formulations has caused only very mild irritation when applied to either intact or abraded skin of rabbits (Braun and Killeen 1975b, a, Sauer 1980 b). Dermal exposure in humans can cause tingling and pruritus with blotchy erythema on exposed skin, and has caused transient paresthesia (ATSDR 2003).

In humans, acute effects observed subsequent to ingestion of permethrin included nausea, vomiting, abdominal pain, headache, dizziness, anorexia, and hypersalivation. Reports of severe poisoning are rare and usually follow ingestion of substantial, but poorly described, amounts of permethrin. Symptoms of severe poisoning include impaired consciousness, muscle fasciculation, convulsions, and noncardiogenic pulmonary edema (ATSDR 2003). Dermal exposure in humans can cause tingling and pruritus (itchy sensation) with blotchy erythema (reddening of the skin) on exposed skin. Systemic effects are similar to those seen in acute and chronic ingestion with prolonged contact or contact with high concentrations of permethrin. Acute toxicity to permethrin via inhalation has been shown to be very small. The 4-hour LC50 was 23.5 mg/L for inhalation in rats (Kidd and James 1991).

The USEPA (2006a) has classified permethrin as category III for acute oral and acute dermal toxicity; category III for eye irritation potential, and category IV for dermal irritation potential. Technical grade permethrin is not considered a skin sensitizer (USEPA 2006a). Permethrin is included in the final list of chemicals for screening under the USEPA Endocrine Disruptor Screening Program (USEPA 2009a).

4.1.10.3 Ecological Toxicity

Permethrin can be toxic to wildlife at high doses and it should not be applied or allowed to drift to crops or weeds where active foraging takes place (USEPA 2006d). However, in controlled toxicity tests with rats as mammalian surrogates permethrin is considered to have low mammalian toxicity (Cantalamess 1993). Permethrin has low toxicity to dogs (Richardson 1999), gerbils, guinea pigs, hamsters, mice and rats (Cantalamessa 1993, Sutton et al. 2007); however, dermal exposure in cats of 100 mg/kg of permethrin (equivalent to 1 mL of a 45 percent PSO in a 4.5 kg cat) has resulted in life-threatening effects (Hansen 2006).

Permethrin is practically nontoxic to birds (USEPA 2006d). The acute 5-day dietary LC50 for mallard ducks is >10,000 mg/kg/day.

Permethrin is very highly toxic to fish and aquatic invertebrates. The 96-hr LC50 for bluegill sunfish is 0.79 µg/L. The EC50 for *Hexagenia bilineata* is 0.1 µg/L (USEPA 2006d).

Permethrin is highly toxic to bees in laboratory conditions from contact exposure. Acute contact and oral toxicity reported by USEPA (USEPA 2006d), was an LD50 of 0.13 µg/bee and 0.024-µg/bee, respectively. MacBean (2012) has reported a higher contact effects value of 0.029 µg/bee. Theiling and Croft (1988) indicate that severe losses may be expected if bees are present at the time of treatment, or within a day thereafter. However, when used properly, permethrin has a strong repellent effect in the environment and has been considered to pose little risk to bees (USEPA 2006d).

4.1.10.4 Ecological Toxicity associated with ULV Application for Mosquito Abatement

Deposition of permethrin following truck-mounted application was evaluated in large seasonal wetlands in California (Jensen et al. 1999). Permethrin was not detected (<20 µg/L) in surface waters 1 hour after ULV applications. The authors found no significant differences in macroinvertebrate abundance and biomass or species diversity in areas treated with any of the materials when compared with untreated ponds. No mortality occurred in mosquitofish held in sentinel cages in treated ponds. Similarly, no difference in mortality was observed for mosquito larvae held in sentinel cages in treated ponds when compared with untreated ones. The authors concluded that ULV applications for adult mosquito control were not likely to significantly affect aquatic insects or fish in these habitats.

Davis and Peterson (2008) measured family diversity, richness, and evenness at 1, 7, 14, and 28 days after truck application of permethrin. Most response variables showed no significant treatment effect, although there were some reductions in number of individuals. The authors concluded that the reductions in aquatic non-target populations did not suggest any trends or persistent deleterious biological effects following a single adulticide application. Significant differences for the pond study were found on the dates closest to the spray event.

Pierce et al. (2005) evaluated deposition after two permethrin ULV applications made with truck-mounted equipment on Key Largo, Florida. They collected samples in the Atlantic Ocean and Florida Bay on either side of the treated area, including measurement of pesticide residues on glass fiber pads set on floats above the water surface, and water collected from the surface microlayer and 20 centimeters below the surface. Water was sampled from a canal running through the treated area following a third application. With the exception of a 0.07 µg/L sample from the bay, permethrin was not detected in the offshore samples; however, permethrin was detected in samples of the water surface microlayer taken from the canal. Detection of permethrin occurred in samples of the surface microlayer taken 2 to 4 hours after the applications (5.1 to 9.4-µg/L). Samples taken below the water surface did not contain detected residues. Within 12 hours of the application, permethrin was undetected in either surface microlayer or subsurface water. The application was carried out shortly before the arrival of a hurricane, and droplet size was not reported. This is the only published study in which significant amounts of pesticide were detected following an application by truck-mounted equipment. This study did not measure PBO concentrations.

4.1.10.5 Summary of Toxicity and Potential Effects

Permethrin may also be persistent in environments free of light (e.g., bound to organic matter in anoxic soils and sediments). Due the potential for persistence and high toxicity to both aquatic and estuarine/marine fish and invertebrates, as well as the potential for endocrine disruption, this RUP may be of concern from a potential ecological risk perspective.

Permethrin is used by three Districts for mosquito or yellow jacket wasp control during the spring, summer, and fall. Four products containing permethrin were used during the reporting year. Some Districts reported permethrin use in volume while others reported use by weight. For the reporting year, approximately 3 ounces (weight) and approximately 20 ounces (volume) of permethrin were applied. These products were used in reclaimed marshes, around residences, and applied directly to yellow jacket ground nests. Three of the products used contain between 2.5 and 4.6 percent permethrin. The fourth and most commonly used product contains 0.25 percent permethrin.

Studies have shown rapid dissipation/low persistence and no observed aquatic fish and invertebrate toxicity following aerial ULV applications; however, these studies are limited and inconclusive. Based on its potential for endocrine disruption, usage patterns, as well as the availability of safer alternatives for wasp control this product is generally used with careful and strict BMP applications.

In addition to the toxicity values referenced in Sections 4.1.10.2 and 4.1.10.3, several toxicity values for Dother species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.1.11 Etofenprox

Etofenprox is a pyrethroid-like insecticide registered by the EPA since 2001. Similar to pyrethroids, etofenprox acts on ion channels of the insect nervous system. It is used as an insecticide with contact and stomach action against many pests on a broad range of crops. Etofenprox differs in structure from pyrethroids in that it lacks a carbonyl group and has an ether moiety, whereas pyrethroids contain ester moieties. It is used as an indoor nonfood crack and crevice insecticide, a spot treatment for pets, and as an outdoor fogger to control a variety of insect pests. Etofenprox is used in backyards, patios, barns, picnic areas, and other areas where flying and crawling insects are a problem. It is also used as a mosquito adulticide.

4.1.11.1 Environmental Fate

Etofenprox is virtually insoluble in water, stable to hydrolysis, and is rapidly degraded with light (Table 4-10). In water/sediment systems, etofenprox degrades relatively quickly. Residues of etofenprox are not likely to persist in the environment (FAO-WHO 2011).

Table 4-10 Degradation of Etofenprox

Degradation Method	Half-life	Reference
Hydrolysis	Stable	FAO-WHO 2011
Photolysis (water)	1.7 to 7.9 Days	FAO-WHO 2011
Photolysis (soil)	4.4 Day	FAO-WHO 2011
Water/sediment systems (water)	1 to 10 Days	FAO-WHO 2011
Water/sediment systems (sediment)	6 to 20 Days	FAO-WHO 2011

4.1.11.2 Human Toxicity

Etofenprox has low acute toxicity via the oral, dermal, and inhalation routes. It is not an acute eye or skin irritant and is not a dermal sensitizer, however etofenprox does cause skin irritation after repeated exposure (USEPA 2008a).The acute oral and dermal LD50 values in rats are both greater than 2,000 mg/kg (Table 6-1). The acute oral LD50 value in the dog is greater than 5,000 mg/kg (Table 6-1). The acute 4-hour inhalation LC50 value in the rat is greater than 5.88 mg/L (Table 6-1. Etofenprox did not exhibit irritation to rabbit skin or rabbit eyes. Etofenprox was not a skin sensitizer in the guinea-pig maximization test (FAO-WHO 2011). The major target organs of etofenprox are the liver, thyroid, kidney, and hematopoietic system (EPA 2008a). In rats the target organs are the liver and thyroid. The NOAEL for chronic toxicity is 3.7 mg/kg/day for male rats. The target organ in mice is the kidney. The NOAEL is 3.1 mg/kg/day for mice (Wellmark International 2010).

4.1.11.3 Ecological Toxicity

Etofenprox is toxic to aquatic organisms, including fish and invertebrates. The LC50 for rainbow trout is 3.3 µg/L and the LC50 for bluegill is 8.5 µg/L. Product formulations are toxic to bees exposed to direct treatment on blooming crops and weeds (Wellmark International 2010). MacBean (2012) reports oral and contact LD50 values of 0.27 and 0.13 µg/bee respectively.

SWRCB has evaluated freshwater aquatic life toxicity data from USEPA Office of Pesticides' Ecotoxicity Database and has identified the lowest LC50 for etofenprox as 0.019 µg/L. This value is based on toxicity to mysid shrimp during a 96 hour test (SWRCB 2012).

4.1.11.4 Summary of Toxicity and Potential Effects

Etofenprox does not tend to persist in the environment or appear to pose a risk to mammals as it is frequently applied to backyards and patios, and sometimes directly to domestic pets. It does exhibit some toxicity to fish and aquatic invertebrates; however, it degrades rapidly in surface waters thereby reducing the potential for long-term exposures and adverse effects.

Etofenprox was applied as a single application to a waste treatment plant in both fall and summer by one District during the reporting year. Approximately 14-ounces (volume) of etofenprox was used for the two treatments. It is generally applied during the nighttime hours when sensitive receptors such as honeybees are not active. Etofenprox is available in a new product, Zenivex that does not require synergists such as PBO. Therefore, it likely exhibits less toxicity than others that require co-application with other chemicals, including synergists to increase its efficacy for mosquito control. Based on toxicity, environmental fate, and usage patterns, etofenprox, using BMPs, is not likely to result in unwanted adverse impacts.

In addition to the toxicity values referenced in Sections 4.1.11.2 and 4.1.11.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British

Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.1.12 Piperonyl Butoxide

PBO was first registered in the 1950s and acts as a synergist. Synergists are chemicals that primarily enhance the pesticidal properties of other active ingredients, such as pyrethrins and synthetic pyrethroids. PBO is a registered active ingredient in products used to control many different types of flying and crawling insects and arthropods, although there are no products that contain only PBO. It is registered for use in agricultural, residential, commercial, industrial, and public health sites. PBO interferes with the insect's ability to detoxify pyrethrins and pyrethroids, thus enhancing the product's effectiveness. PBO inhibits microsomal enzymes in target organisms by direct binding to these enzymes and inhibits the breakdown of other pesticides including pyrethrins and pyrethroids (USEPA 2006e).

4.1.12.1 Environmental Fate

PBO degrades rapidly in the environment by photolysis in water and is metabolized by soil microorganisms (Table 4-11). Other tested routes of degradation, such as hydrolysis, aerobic and anaerobic aqueous metabolism, are very slow or have questionable rates due to experimental difficulties, as in the case of soil photodegradation. PBO is moderately mobile in soil-water systems (USEPA 2006e).

Table 4-11 Degradation of Piperonyl Butoxide

Degradation Method	Half-life	Reference
Hydrolysis, pH 5-9	Stable	USEPA 2006e
Photolysis (water)	8.4 Hours	USEPA 2006e
Aerobic metabolism (water/sediment)	>30 Days	USEPA 2006e
Anaerobic metabolism (water/sediment)	>181 Days	USEPA 2006e
Terrestrial dissipation (soil)	1 to 14 Days	USEPA 2006e

4.1.12.2 Human Toxicity

PBO has a low acute toxicity by oral, inhalation and dermal routes. It has been assigned toxicity USEPA Category III by oral and dermal and Category IV by inhalation exposure routes. In the acute studies, PBO has been identified as minimally irritating to eyes and skin, and is a dermal sensitizer. The oral LD50 was 4,570 to 7,220 mg/kg in rats, the dermal LD50 was found to be greater than 2,000 mg/kg in rabbits, and the inhalation LC50 was found to be greater than 5.9 mg/L in rats (USEPA 2006e) (Table 6-1). The major target organ for PBO is the liver. Subchronic studies in rats showed PBO treatment caused increases in liver weight and clinical parameters such as cholesterol and enzyme activity compared to controls (USEPA 2006e). PBO is included in the final list of chemicals for screening under the USEPA Endocrine Disruptor Screening Program (USEPA 2009a).

4.1.12.3 Ecological Toxicity

PBO is moderately toxic to freshwater fish on an acute basis (LC50 = 1.9 mg/L) based on studies of rainbow trout (*Oncorhynchus mykiss*). PBO ranges from moderately toxic (LC50 = 12.0 mg/L) to highly toxic (LC50 = 0.51 mg/L for waterflea, *Daphnia magna*) to freshwater invertebrates on an acute basis. PBO is moderately toxic to estuarine/marine fish (LC50 = 3.94 mg/L) based on observed effects to sheepshead minnow (*Cyprinodon variegatus*) on an acute basis. PBO is highly toxic to estuarine invertebrates (LC50 = 0.49 mg/L) based on studies with mysid shrimp (*Mysidopsis bahia*). PBO is highly toxic to amphibians on an acute basis (LC50 = 0.21 mg/L) based on studies with western chorus frog tadpoles (*Pseudacris triseriata*) (USEPA 2006e).

A chronic early life stage of fish study with fathead minnow evaluated embryo survival at hatch and length and weight of larvae. This study found a LOEC of 0.11 mg/L. A study with water fleas found a LOEC of 0.047 mg/L (USEPA 2006e)

SWRCB has evaluated toxicity data from U.S. EPA's Office of Pesticides' Ecotoxicity Database for PBO when applied in formulation with pyrethrins. The lowest LC50 was 0.14-µg/L, based on toxicity to mysid shrimp during a 96-hour test. Toxicity data was also evaluated for PBO when applied in formulation with resmethrin. SWRCB identified the lowest LC50 as 1.3 µg/L based on toxicity to pink shrimp during a 96-hour test. For PBO applied in formulations other than pyrethrins or resmethrin, SWRCB identified the lowest LC50 as 490 µg/L based on toxicity to mysid shrimp during a 96-hour test (SWRCB 2012). PBO is practically nontoxic to honey bees on an acute oral basis (LD50 >25 µg/bee) (USEPA 2006e).

4.1.12.4 Ecological Toxicity associated with ULV Application for Mosquito Abatement

Following aerial applications of Evergreen Crop Protection EC 60-6 (6 percent pyrethrins, 60 percent PBO) in Sacramento for West Nile virus, Larry Walker Assoc. (2006) reported results of water testing on samples from 10 waterways within the treatment area. Treated areas were sprayed nightly for 3 days. One additional application occurred 9 days prior to the 3-day event at selected locations. Samples were taken immediately after application (within 1 to 6 hours), and the next day (16 to 23 hours after the application). Piperonyl butoxide was detected in water from 14-of the 25 samples collected after the application. Concentration of PBO ranged from <1.0 to 20 µg/L (average 2.036 µg/L) immediately after application. PBO concentrations ranged from <1.0 to 4.2 µg/L with an average of 0.853 µg/L in samples taken between 16 and 23 hours after application. Of the 31 samples taken between 16 and 23 hours after application, PBO was detected in 11 samples. Water samples were tested eight days following aerial applications, from four sites. No PBO was detected in any of these samples, therefore, the duration of persistence of PBO appears to be greater than 16 hours, but less than 1 week.

Testing was also carried out by Weston et al. (2006) following the same applications. Prior to aerial spraying, PBO was not detected in sediment samples; however, PBO was detected at 0.2 µg/L in 2 of 4 water samples. PBO was detected in water (0.44-to 3.92 µg/L, all 7 samples) and sediment (16 to 61.4 µg/kg, for 4-of 6 samples) at 10 to 34-hours after application. Neither water nor sediment was tested at later intervals, so the duration of persistence could not be determined in this study. Laboratory tests were conducted to determine the effects of short-term chronic exposure of *Ceriodaphnia dubia* to water collected after the spray events, following USEPA protocol. No significant differences in mortality were observed. In addition, sediment toxicity tests were performed with the amphipod *Hyalella azteca,* and toxicity was observed in samples collected both before and after application. The authors concluded that pyrethrins and PBO should present little risk to aquatic organisms due to the low toxicity and lack of long-term persistence, but that PBO had the potential to enhance toxicity of other pesticides, especially pyrethroids, already present in the environment. Weston et al. (2006) performed additional laboratory tests to determine the effect of PBO on toxicity of pyrethroids present on sediment, and found that even by removing 80 percent of the overlying water and replacing it with fresh PBO solution daily, within 24-hours, over 30 percent of PBO is lost, most likely to photo degradation. The results indicated that most sediments present at the creeks used for this study already contained concentrations of pyrethroids acutely lethal to *H. azteca* from urban uses not related to mosquito control activities.

Water and soil deposition of pyrethrins and PBO following aerial applications was evaluated at two sites in California (Schleier III et al. 2008). Water was sampled after aerial applications of pyrethrins and PBO in irrigation ditches at one site (Princeton) and in static ponds at another (Colusa). PBO was detected at low levels and decreased exponentially with time. Average PBO concentrations were 0.0125 to 0.0199 microgram per square centimeter (µg/cm^2) on ground deposition pads and 0.1723 to 1.274-µg/L in water samples, immediately following the applications. Within 36 hours of the applications, PBO had decreased to background levels in water. Concentrations of PBO decreased 77 percent between 1 and 12 hours after the spray event. The authors concluded that the amounts of pyrethrins and PBO deposited

on the ground and in water after aerial ULV insecticide applications are probably lower than those estimated by previously published studies to predict exposure and risk.

Lawler et al. (2008) evaluated pyrethrins and PBO in sediment following multiple applications of pyrethrins formulated with PBO from truck-mounted equipment in the Colusa and Sacramento National Wildlife Refuges in California. Stock tanks were filled with a layer of soil overlain with 1,150 liters of water. Zooplankton (*Daphnia magna*) were held in sentinel cages in the water column and mayfly larvae (*Callibaetis californicus*) were placed in cages at the bottom of each tank, where they were in contact with sediment. ULV applications of pyrethrins formulated with PBO were made from truck-mounted equipment twice weekly for six weeks. Concentration in sediments and sentinel survival were evaluated after application 5 and 11. PBO concentrations ranging from 8.37 to 14.9 µg/kg were seen in 5 of 6 tanks after five applications, but in only 2 of 6 tanks after 11 applications (1.93 and 2.55 µg/kg). There was no significant difference in mortality for mayfly larvae held in sentinel cages on the sediment. Likewise, there was no significant difference in mortality seen in *D. magna* held in the water column. They concluded that applications of pyrethrins and PBO at rates used for mosquito control did not have detectable effects on the indicator species. The persistence of PBO in sediment was not evaluated in this study. PBO-synergized pyrethrins had no detectable effect on the survival of *D. magna* held in tanks in the spray area, even after 11 biweekly spray events.

Amweg et al. (2006) evaluated deposition of PBO in water and sediment following truck-mounted applications of synergized pyrethrins to a freshwater wetland in Colusa County in 2004. PBO was detected in 2 of 18 sediment samples above the reporting limit of 2.0 µg/kg, at 3.27 and 3.0 µg/kg, respectively. PBO was detected in 3 of 10 samples of water at concentrations above the reporting limit of 0.01 µg/L, ranging from 0.04-to 0.08 µg/L. The highest concentrations of PBO were observed in samples obtained within 12 hours of spraying; concentrations in water and sediment were below the reporting limit in samples taken one week after the last ULV application (Amweg et al. 2006).

Several papers were published documenting that ULV-applied mosquito adulticides do not accumulate to any significant degree in water or sediment during repeated applications. Chemical testing was conducted following multiple spray events in 2006 by Amweg et al. There was no increase in the level of pyrethrins or PBO following multiple daily spray events, and the concentration had returned to background level when samples taken one week after the last application were tested. Similarly, Lawler et al. (2008), reported that the concentration of pyrethrins and PBO in tanks within a treated area were not significantly higher after 11 applications than in samples taken after the fifth application. In many cases, the concentrations were actually lower following the 11th spray event than after the fifth spray event. Accumulation of PBO was evaluated by Amweg et al. (2006). PBO did not accumulate in water or sediment, even after eight biweekly applications by truck-mounted equipment over the course of two months.

ULV applications of the resmethrin formulated with PBO in Suffolk County New York have been evaluated (Abbene et al. 2005). Deposition of resmethrin and PBO following truck-mounted applications in fresh and salt water marshes was assessed at 6 sites. PBO was detectable at low levels (0.008 µg/L and 0.017 µg/L) in 2 of 6 water samples taken immediately after the application. Deposition of resmethrin and PBO following aerial applications by helicopter was assessed in the same report (Abbene et al. 2005). Applied materials were detected in some water samples taken within 30 minutes of the application. PBO was detected more frequently than resmethrin, and detection of PBO was more common after helicopter applications (83 percent) than following those carried out by truck (33.3 percent). The average concentration of PBO was 4.361 µg/L. The highest concentrations were found in some samples collected from surface water within 1 hour of helicopter applications (59.8 µg/L PBO). The authors carried out a series of sample collections after two spray events to evaluate the persistence of the materials in water. PBO was not detected (<0.005 µg/L) in samples taken 96 hours after the application (Abbene et al. 2005). One site included two repeat weekly applications of resmethrin following an application of methoprene the

prior week. Concentrations of resmethrin and PBO measured after the second application were lower than those measured after the first application.

The same study included effects of aerial applications of resmethrin and PBO on two aquatic organisms: the sheepshead minnow (*Cyprinodon variegatus*) and the estuarine grass shrimp (*Palaemonetes pugio*) (Suffolk County 2006). The field study faced problems with low dissolved oxygen and high temperature, which compromised their ability to detect toxicity that may have been due to pesticide exposure. Therefore, dosing experiments and prey capture tests were conducted in the laboratory to measure toxicity of the applied products. These tests demonstrated that the doses used in the spray were not directly toxic to grass shrimp and did not affect their ability to capture prey under controlled conditions. Further laboratory experiments demonstrated that all of the mortality seen in the field could have been caused by low dissolved oxygen alone, using a USEPA time-to-death approach. Furthermore, their data showed that the chemicals used had very low persistence in the water column, as discussed above. PBO was last detected in samples taken 48 hours after the spray.

Another related study evaluated benthic community structure, and found that benthic population differences could not be attributed to the application of pesticides, but were more likely due to environmental differences (Suffolk County 2006).

Zulkosky et al. (2005) sampled freshwater ponds, salt marshes, tidal inlets and embayments, and marine coastal water off Staten Island, New York within an hour after mosquito control applications of resmethrin formulated with PBO (Scourge). PBO was detected in all but one location at concentrations ranging from 0.0006 to 15 µg/L. PBO was still present at three locations in samples collected three days after a Scourge spray. No information was provided on application methods at each site. Zulkosky et al. (2005) also evaluated phenothrin (in formulation with PBO) applied as Anvil. In 2002, PBO was detected in all samples at concentrations ranging from 0.0003 to 0.0007 µg/L. In 2003, PBO was detected at 0.020 µg/L immediately after spraying Anvil and was found at concentrations ranging from <0.0005 to 0.007 µg/L 10 days later.

New York City Department of Health sampled 32 locations for phenothrin formulated with PBO before and after spray events during mosquito adulticide applications that occurred during July through September 2000. Out of the 68 post-application samples collected by the city, only one sample had concentrations of PBO greater than the 0.5 µg/L reporting limit: 1.03 µg/L for PBO for a sample collected on August 5, 2000, at Alley Park Pond in Queens (Suffolk County 2006).

The Massachusetts Department of Agricultural Resources conducted a study where phenothrin formulated with PBO was applied aerially as Anvil 10+10 ULV to six sites. There were no detections of phenothrin during this study; however, PBO was detected at 0.12 µg/L. (Massachusetts Department of Agricultural Resources 2010).

Davis and Peterson (2008) also evaluated phenothrin formulated with PBO and applied as Anvil 10+10 ULV. The authors concluded that the reductions in aquatic non-target populations did not suggest any trends or persistent deleterious biological effects following a single adulticide application.

4.1.12.5 Summary of Toxicity and Potential Effects

PBO has been an effective synergist used in mixtures with other insecticidal active ingredients since the 1950s. It degrades rapidly in soil and water and, therefore, does not tend to persist in the environment. PBO may be highly toxic to some species of fish and aquatic invertebrates and is being evaluated as a possible endocrine disruptor.

PBO is contained as a secondary ingredient along with pyrethrin, resmethrin, and permethrin in several products used by eight Districts. These products are used throughout the year in manmade and natural sites with standing and moving water, as well as tree holes, ditches, and residential areas. There were several hundred applications during the reporting year. It is generally applied using ULV techniques,

which are designed for low chemical persistence and toxicity to non-target receptors. PBO is not expected to pose risk to aquatic organisms especially when applied using ULV techniques; however, it has been shown to have the potential to enhance toxicity of other pesticides and should be considered when it is an additive to a pesticide formulation.

In addition to the toxicity values referenced in Sections 4.1.12.2 and 4.1.12.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.2 Organophosphate Insecticides

4.2.1 Naled

Naled is an organophosphate insecticide that has been registered since 1959 for use in the U.S. It is used in rotation with pyrethrins or pyrethroids for control of adult mosquitos to avoid the development of resistance. In addition to use for controlling adult mosquitoes, naled also has indoor and outdoor general use, and is used on food and feed crops, farms, dairies, pastureland, and in greenhouses and over standing water (CDPR 2010a). Dichlorvos (DDVP), a registered OP insecticide, is a metabolite of naled (USEPA 2006c).

4.2.1.1 Environmental Fate

Naled is readily degraded in water, under sunlight, in soil under aerobic and anaerobic conditions (Table 4-12), in the air, and on plants. On plant surfaces, naled is degraded to DDVP. Naled is more mobile in soil of low organic content such as sandy loam when compared with other soil types (CDPR 1999). Naled has low water solubility and can volatilize (CDPR 1999, 2001).

Table 4-12 Degradation of Naled

Degradation Method	Half-life	Reference
Hydrolysis, pH 5 (water)	96 Hours	CDPR 1999
Hydrolysis, pH 7 (water)	15.4 to 17 Hours	CDPR 1999
Hydrolysis, pH 9 (water)	1.6 to 1.7 Hours	CDPR 1999
Photolysis (water)	3.7 to 4.4-Days	CDPR 1999
Photolysis (plant surfaces)	<5 Days	CDPR 1999
Aerobic metabolism (soil)	3 Days	CDPR 1999
Anaerobic metabolism (soil)	6 Days	CDPR 1999

4.2.1.2 Human Toxicity

Naled is rapidly absorbed by all routes (oral, inhalation, and intraperitoneal) and distributes to all tissues in the rat, chicken, goat, and cow. The oral LD50 for naled technical grade active ingredient is 81 to 336 mg/kg in rats or mice, the dermal LD50 is 354-to 800 mg/kg in rats or rabbits, and the nose exposure inhalation LC50 is as low as 0.19 in rats (CDPR 1999).

4.2.1.3 Ecological Toxicity

Naled technical grade active ingredient was found to be moderately toxic to highly toxic to wide range of species including rainbow trout (LC50 = 0.08 mg/L), blue gill (LC50 = 2.2 mg/L), sheepshead minnow (LC50 = 1.2 mg/L), mullet (LC50 = 0.55 mg/L), daphnia (LC50 = 0.35 µg/L), pink shrimp

(EC50 = 5.5 µg/L), grass shrimp (LC50 = 8.9 mg/L), and eastern oyster (EC50 = 0.19 mg/L). Lethal effects were also found in honey bees (LD50 = 0.48 µg/bee) and mallards (LD50 = 52 mg/kg) (CDPR 1999).

SWRCB has evaluated the U.S. EPA's Office of Pesticides' Ecotoxicity Database to access toxicity of naled to freshwater aquatic life and has identified LC50 values that range from 0.14 to 3,300 µg/L (SWRCB 2012).

4.2.1.4 Ecological Toxicity associated with ULV Application for Mosquito Abatement

Tucker et al. (1987) evaluated deposition and non-target effects for truck-mounted and aerial applications of naled. The maximum concentration of naled in water samples following truck applications (0.71 µg/L) occurred 15 minutes after the application. The concentration in water decreased exponentially after this; detected concentrations persisted for 4-hours. No significant mortality was observed in copepods or fish exposed from truck-mounted applications. The same study evaluated deposition of these materials following applications made from aircraft (Tucker et al. 1987). The maximum concentration of naled in water samples following aerial applications (20.15 µg/L) occurred 27 minutes after the application. The concentration in water decreased exponentially after this; detected concentrations persisted for 9 hours. Deposition rates for naled from aerial applications were much higher (47 to 68 percent) than those resulting from ground applications (21 to 22 percent). The authors reported significant mortality in copepods held in sentinel cages in the treated area and exposed to naled by aerial application. No significant mortality was observed for juvenile fish held in the treated area. This is the only report of significant mortality in aquatic organisms following a ULV application. The size of droplets released is not given and the amount of material recovered from glass filter pads placed on the ground was unusually high. Perhaps the conditions of the applications resulted in a greater proportion of the product reaching the ground.

In what may have been the same study, Wang et al. (1987) also investigated the fate of naled after aerial ULV applications of mosquito adulticides at a salt marsh in Florida. Approximately 30 minutes after application, the concentration of naled in the water was 20.15 µg/L, decreasing to 0.2 µg/L at 6.45 hours, and was not detected at 12.45 hours (detection limit of 0.05 µg/L). The peak concentration of dichlorvos (a breakdown product of naled) was 2.22 µg/L approximately 30 minutes after application, and was still detectable at 12.45 hours (0.28 µg/L).

Deposition of naled during aerial applications was also evaluated (Pierce et al. 2005). Naled was detected in low concentrations (0.19 µg/L) in the water surface microlayer at 1 of 18 sites. It was not detected in subsurface water (detection limit 0.05 µg/L). Residues were not detectable in the water surface microlayer 12 hours after the application. Dichlorvos, a breakdown product of naled, and itself a registered pesticide, was detected at 2 to 4 hours after the application. Trace amounts were still detectable at 10 to 12 hours post-treatment.

4.2.1.5 Summary of Toxicity and Potential Effects

Naled has low water solubility and is mobile in some soils. It is moderately toxic to mammals, fish, and aquatic vertebrates. Naled was not used by the Districts during the reporting year.

In addition to the toxicity values referenced in Sections 4.2.1.2 and 4.2.1.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.2.2 Temephos

Temephos is a cholinesterase inhibitor registered by the EPA in 1965 to control mosquito larvae (USEPA 2000). Temephos is the only organophosphate with larvicidal use and is often used to help prevent mosquitoes from developing resistance to the bacterial larvicides. Temephos is used on lakes, ponds,

reservoirs, swamps, marshes, tidal areas, intermittently flooded areas, catch basins, drainage systems, irrigation systems, ornamental ponds, wastewater, polluted and stagnant water, and is applied by mosquito abatement Districts (CDPR 2010a). MVCAC member agencies primarily apply temephos to manmade sources such as tire piles, utility vaults, and cemetery urns. Mosquito control products containing temephos are not labeled for application to agricultural lands or pasture and are not used in such sites. Temephos provides effective control of mosquito larvae in highly polluted water (containing high levels of decaying organic matter, such as rotting leaves or manure).

Temephos is a broad-spectrum insecticide and has also been used operationally to control midges and black flies for many years. However, the concentration that effectively controls mosquito larvae is well below that needed for control of other insects. In addition, midges and black flies are found in different habitats than larval mosquitoes. The larval stage of most midges develop in sediment at the bottom of water bodies, while black flies develop attached to hard surfaces in swift moving rivers and streams. Materials commercially available for midge control are heavy and designed to release their active ingredients on the floor of the water body and those for control of black flies are placed in flowing streams and allowed to move down with the current.

4.2.2.1 Environmental Fate

The presence of microorganisms in aquatic environments and exposure to sunlight are likely to be the predominant means of transformation/dissipation of temephos (Table 4-13) (USEPA 1998a). Temephos is an extremely hydrophobic material with low solubility. It adsorbs rapidly onto organic material in the water and binds strongly to soils. Temephos breaks down in water through photodegradation and bacterial degradation (USEPA 2000).

Table 4-13 Degradation of Temephos

Degradation Method	Half-life	Reference
Hydrolysis	>86 Days	USEPA 1998a
Photolysis (water)	15 Days	USEPA 1998a
Aerobic metabolism (water)	17.2 Days	USEPA 1998a
Anaerobic metabolism (water)	12.2 to 27.2 Days	USEPA 1998a

The RED cites a study submitted by the registrant in which temephos was monitored in sediments following field applications for mosquito control over a 3-year period. The active ingredient became undetectable in sediment after 24 hours (USEPA 2000). Lores et al. (1985) found that concentrations in water of 15 to 60 ppb immediately following the application declined to 2 to 5 ppb within 24 hours. Sanders et al. (1981) reported similar results. Pierce et al. (1989) examined aerial application of liquid formulation of temephos to a mangrove swamp in Florida, and found the material had become undetectable 4-hours after the application in intertidal water. It persisted in simulated intertidal pools for 72 hours. The liquid and BG formulation products are designed to deliver the active ingredient to the water surface in order to maximize exposure of mosquito larvae.

4.2.2.2 Human Toxicity

Temephos is moderately toxic via the oral, dermal, and inhalation routes. The oral LD50 in rats is 444-mg/kg. The dermal LD50 in rabbits is 970 mg/kg. The inhalation LC50 in rats is 1.3 mg/L (USEPA 2012). MacBean (2012) reports significantly different values with the oral LD50 for male and female rats being 4204 and >10000 mg/kg respectively, the dermal LD50 for rats being 2,181 mg/kg, and the inhalation LC50 being 4.79 mg/L. (Table 6-1).

4.2.2.3 Ecological Toxicity

Temephos has low toxicity for vertebrates at the levels used for mosquito control (USEPA 2000). However, it is toxic to insects and some other invertebrates (Brown et al. 1996), and the margin of safety between concentrations effective for mosquito control and levels at which non-target impacts occur is much narrower than that of s-methoprene or the bacterial larvicides (Brown et al. 1999, Lawler et al. 1999, Hurst et al. 2007).

Temephos is slightly to moderately toxic to fish (USEPA 2000); however, field applications result in concentrations of temephos far lower than that at which fish are affected. Field studies have repeatedly demonstrated a lack of impact on fish inhabiting treated sites. Mulla et al. (1964) reported that temephos was nontoxic to mosquito fish that were confined in screened cages for one week in artificial ponds treated with 0.1 pound per acre AI. Similarly, no significant mortality was observed in juvenile snook (*Centropomis undecimalis*) or sheepshead minnow (*Cyprinodon variegatus*) caged in a mangrove swamp treated with aerial applications of liquid temephos (Pierce et al. 1989). Tietze et al. (1991) demonstrated laboratory tests that liquid formulations of temephos were nontoxic to young mosquitofish (3 to 5 days old) at field application rates. Mosquitofish exhibited no mortality when exposed to up to 100 times field application rates.

Temephos is highly toxic to aquatic invertebrates, but many groups are only impacted at concentrations far above those used for mosquito control applications (USEPA 2000). Von Windeguth and Patterson (1966) conducted laboratory tests on temephos and fenthion (another organophosphate) to determine margin of safety for treatment of midges in a lake. The dose of fenthion used for midges was above that which caused mortality in shrimp and amphipods. Abate (temephos) was less toxic to most aquatic non-target organisms than fenthion and not toxic to shrimp (*Palaemonetes paludosus*) and amphipods (*Hyalella azteca*) at concentrations used for mosquito control applications (LD50 was 1 mg/L and 0.65 mg/L, respectively). Neither product was toxic to fish at levels necessary to kill midge larvae (0.25 lb active ingredient per acre). In field tests, they reported that no noticeable mortality was observed for Odonates (dragonflies), copepods, ostracods, or shrimp (Von Windeguth and Patterson 1966).

Temephos does have an immediate impact on some groups of planktonic crustaceans, with copepods and brachiopods (*cladocera*) being more sensitive than amphipods or ostracods. Fortin et al. (1987) studied the impact of temephos on non-target organisms in rectangular manmade ponds. Application of temephos resulted in an immediate reduction in populations of copepods and cladocerans, but populations began to recover within 3 days and had reached pre-treatment levels within 2 to 3 weeks. Ostracods in the ponds were not affected. Helgen et al. (1988) also reported sharp reductions in populations of calanoid copepods (*Diaptomus leptopus*) and cladocerans (*Daphnia pulex*, *Simocephalus* sp., and *Chydoridae*) following applications of temephos. Copepods exhibited varying degrees of recovery. However, some cladocerans remained absent from the treated area for up to 35 days. In an open field setting, Lawler et al. (1999) reported that aerial applications of temephos to a mangrove swamp in Florida resulted in no observable effect on survival of amphipods (*Talitridae*), the primary non-target organism present.

Several studies have evaluated effects on non-target insects. A field study of repeated applications of temephos to a saltmarsh in New Jersey concluded that species richness, diversity, and community structure of aquatic insects was unaffected (Campbell and Denno 1976). Stoneflies and mayflies are particularly susceptible to temephos and the label carries a prohibition against applying Abate in habitats containing these organisms.

Among the materials available for control of mosquito larvae, temephos has the narrowest margin of impact and the greatest potential for effects to non-target organisms. However, it is an effective method of control in isolated sources that may be difficult to treat by other means, such as sources with high concentrations of organic material, and ones in which other less toxic alternatives have failed to produce adequate levels of control. Temephos was in widespread use in California for control of larval mosquitoes

from 1965 into the mid-1980s. The microbial pesticides, methoprene, and surface oils are used much more frequently now and have largely replaced temephos as the method of choice for larval sources in water of the U.S. Temephos is more widely used in other parts of the U.S. such as Delaware, New Jersey, New York, Maryland, and Florida.

4.2.2.4 Summary of Toxicity and Potential Effects

Temephos has extremely low water solubility and binds strongly to soils. It is moderately acutely toxic to mammals and fish, but highly toxic to non-target aquatic invertebrates (e.g., stoneflies, mayflies). The USEPA (2000) states that there is likely no exposure of people to temephos in drinking water or from residential use. It is not expected to have direct impact on terrestrial animals and the use of temephos has declined over time (USEPA 2000). Temephos was used in one product by two Districts during the reporting year. It is typically applied in all four quarters of the year resulting in the use of over 1,000 pounds of product. Active ingredient concentration in this product is 5 percent resulting in a total use of about 50 pounds of AI. Based upon the environmental fate, toxicity, and BMP approaches, the use patterns for temephos should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Sections 4.2.2.2 and 4.2.2.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.3 Mosquito Larvicides

4.3.1 Bacillus sphaericus (Bs)

Microbial larvicides are bacteria that are registered as pesticides for control of mosquito larvae in outdoor areas such as irrigation ditches, flood water, standing ponds, woodland pools, pastures, tidal water, fresh- or saltwater marshes, and stormwater retention areas (USEPA 2007c). The microbial larvicides concentrates registered for use in California include *Bacillus sphaericus* (Bs) and *Bacillus thuringiensis* subspecies *israelensis* (Bti). These concentrates include fermentation solids, bacterial spores, and insecticidal toxins. Their mode of action requires that they be ingested to be effective, which means they cannot be used to control mosquitoes at some life stages (late 4th instar larvae, pupae, and adults). Bs spores contain a protein that damages and paralyzes the gut of mosquito larvae that ingest the *spores*, thus starving the larvae (USEPA 1999). A standard bioassay similar to that used for Bti has been developed to determine preparation potencies.

Bs was first registered by the EPA in 1991 for use against mosquito larvae. Bs can control mosquito larvae in highly organic aquatic environments, including sewage waste lagoons, animal waste ponds, and septic ditches. Bs is used on rice, fruit trees, walnuts, almonds, corn, asparagus, cotton, dates, and other crops. It is also applied to alfalfa, pastures, agricultural drainage systems, animal drinking water, fodder grasses, irrigation systems, swimming pools, ornamental ponds and fountains, catch basins, wastewater, bilge water, industrial processing water, industrial waste disposal systems, solid wastes sites, garbage dumps, and on tidal areas, swamps, marshes, bogs, intermittently flooded areas, standing water, and by mosquito abatement Districts (CDPR 2010a).

4.3.1.1 Environmental Fate

Dormant Bs spores may persist in the environment for several weeks to months; however, the δ-endotoxins generally persist for 2 to 4 weeks following application. Factors affecting its persistence include the formulation of the *B. sphaericus* product, agitation of the waterbody, receiving water quality and temperature. The δ-endotoxins produced by Bs degrade rapidly in sunlight as a result of exposure to ultraviolet radiation and are degraded by soil microorganisms. Bs, as with other soil microbes, does not percolate through the soil and readily binds to sediments within the water column, and is, therefore, not

available to contaminate ground water (Maine Department of Environmental Protection 2010). Field evaluations of VectoLex-CG (a commercial formulation of *B. sphaericus*) have shown environmental persistence for several weeks (Mulla et al. 1988).

4.3.1.2 Human Toxicity

Bs is not pathogenic and does not demonstrate any systemic toxicity. An acute oral toxicity/pathogenicity study was conducted with Bs technical material in rats. An oral dose of approximately 1 x 10^8 colony forming units (CFU) administered to rats resulted in no mortalities, no evidence of pathogenicity or treatment related toxicity in rats given an oral, intratracheal installation or intravenous dose. In an acute oral toxicity study, Bs technical material caused no deaths in rats given a dose of 5,000 mg/kg; therefore the acute oral LD50 was greater than 5,000 mg/kg. There was no mortality in rabbits over the 14-day observation period following a 2,000 mg/kg dermal application for 24-hours; thus, the acute dermal LD50 was greater than 2,000 mg/kg. In a 4-hour acute inhalation toxicity study in rats, the maximum attainable concentration was 0.09 mg/L, with 13.3 percent of the particles having a mass median aerodynamic diameter of >10 microns. Since there was no mortality or no clinical signs during exposure or the 14-day observation period, the 4-hour inhalation LC50 was greater than 0.09 mg/L. Dermal irritation of Bs technical material was moderately irritating to rabbit skin at 72 hours. Irritation and iridal effects following a 100 mg aliquot of Bs placed in the eye of rabbits were no longer present at day 10 post-treatment (USEPA 1997a) (Table 6-1).

4.3.1.3 Ecological Toxicity

Available literature indicates that Bs is not acutely toxic to non-target species, including birds, mammals, fish and invertebrates. Bs has a very low toxicity for fish, and all aquatic invertebrates. Amounts that effectively control mosquito larvae are many levels of magnitude below those, which affect other organisms. Acute aquatic freshwater organism toxicity tests were conducted on bluegill sunfish, rainbow trout and daphnids. The 96-hour LC50 and No Observable Effect Concentration (NOEC) value for bluegill sunfish and rainbow trout was greater than 15.5 mg/L; the 48-hour EC 50 and NOEC value for daphnids was greater than 15.5 mg/L. Acute aquatic saltwater organism toxicity tests were conducted on sheepshead minnows, shrimp and oysters. The 96-hour LC50 value for both sheepshead minnows and shrimp was 71 mg/L, while the NOEC value was 22 mg/L for sheepshead minnows and 50 mg/L for shrimp. The 96-hour EC50 value for oysters was 42 mg/L with an NOEC of 15 mg/L. The LC50 and NOEC value for immature mayflies was 15.5 mg/L. Additional studies on various microorganisms and invertebrates, specifically cladocerans, copepods, ostracods, mayflies, chironomid midges, water beetles, backswimmers, water boatmen, giant water bugs, and crawfish, have shown no adverse effects or negative impacts (Miura et al. 1981, Holck and Meek 1987, Key and Scott 1992, Tietze et al. 1993). Furthermore, Ali (1991) states that although *B. sphaericus* is known to be highly toxic to mosquito larvae, Bs does not offer any potential for midge control.

Applications of Bs also leave populations of mosquito predators intact and do not cause secondary effects when treated larvae are consumed by other insects. Key and Scott (1992) conducted laboratory studies with Bs on the grass shrimp *Palaemonetes pugio* and the mummichog *Fundulus heteroclitus*. Their study indicated that both Bti and Bs larvicides have large margins of safety. In a study by Aly and Mulla (1987), aquatic mosquito predators were fed with *Cx. quinquefasciatus* 4th instar larvae intoxicated with either Bti or Bs preparations. Although the mosquito larvae contained large amounts of the bacterial preparations in their gut, no effect upon longevity or ability to molt was observed in the backswimmer *Notonecta undulata*, in naiads of the dragonfly *Tarnetrum corruptum*, or in naiads of the damselfly *Enallagma civile*. Equally, the reproduction of *N. undulata* and the predation rate and ability to emerge normally in *T. corruptum* and *E. civile* were not affected by ingestion of large amounts of bacterial toxins.

Bs has not been found to have adverse effects on chironomids or any other aquatic species at levels used for mosquito control.

4.3.1.4 Summary of Toxicity and Potential Effects

Bs is an effective microbial pesticide specifically targeted at mosquito larvae. A common member of microbial communities and a natural biological enemy of mosquito larvae, Bs does not exhibit toxicity or risk to non-target organisms. This microbial active ingredient is used by eight of the Districts, typically throughout the year, including during each quarter of the reporting year. Bs is contained in nine products, which are applied to both standing and moving water at natural and manmade sites. Several thousand applications occurred during the reporting year. Concentrations of the active ingredient in these products range from 6 to 51.2 percent.

Based upon the environmental fate, toxicity, and use patterns by the districts during the reporting year, it should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Sections 4.3.1.2 and 4.3.1.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.3.2 Bacillus thuringiensis subspecies israelensis (Bti)

Bti concentrates are made up of the dormant spore form of the bacterium and an associated pure toxin. The toxin disrupts the gut in mosquito larvae by binding to receptor cells (USEPA 2007c). *Bti* organisms produce five different microscopic protein pro-toxins packaged inside one larger protein container or crystal. The crystal is commonly referred to as delta (δ-) endotoxin. This toxin consists of five proteins that are released only under extremely alkaline conditions. Mosquitoes are unique in having very alkaline conditions within the midgut (the stomach of vertebrates contains acid). When a mosquito larva ingests the δ -endotoxin, the five proteins are released in the alkaline environment of the insect larval gut. The five proteins are converted into five different toxins by specific enzymes present in the gut of mosquito larvae. Once converted, these toxins destroy the gut wall, which leads to paralysis and death of the larvae. Bti is toxic to larval stages of all genera of mosquitoes, and to black flies (*Simuliidae*). The dependence on alkaline conditions and the presence of specific enzymes gives this material a high degree of specificity for mosquitoes and black flies. Bti is also used for control of chironomids, but much higher levels are needed for effective control.

An isolate of Bt was first registered by the EPA in 1961 for use as an insecticide (USEPA 1998f). The subspecies israelensis (Bti) was first registered as an insecticide in 1983. One formulation of Bti is used in California for controlling gnats on greenhouse crops, peppers, tomatoes, celery, cabbage, leafy vegetables, cauliflower, walnuts, almonds, dates, corn, asparagus, bananas, fruit trees, and other crops. It is applied for mosquito control on rice, alfalfa, pastures, animal drinking water, ornamental nurseries, ornamental ponds, irrigation systems, swimming pools, drainage systems, lakes, streams, swamps, marshes, tidal areas, standing water, polluted or stagnant water, sewage systems, intermittently flooded areas, catch basins, domestic dwellings, and by mosquito abatement Districts and by ULV application (CDPR 2010a).

4.3.2.1 Environmental Fate

Bti toxins degrade rapidly in the phyllosphere as a result of exposure to ultraviolet (UV) light. Bti toxins may persist in soil for several months, yet a half-life for typical Bti products on foliage is approximately 1 to 4-days (USEPA 1998g).

Generally, Bti persists in the environment for periods measured in days. Factors that affect persistence and efficacy of Bti in the environment may include, but are not limited to, the formulation of the Bti product, agitation of the waterbody, receiving water quality and temperature. Solid and granule formulations, which act through a slow release action, generally persist for longer periods than liquid formulations. Agitation of sediments in the water column acts to resuspend Bti and, therefore, causes the

bacterium to persist as an available pesticide for longer periods. Waters with higher organic content generally require higher doses of Bti due to lower ingestion rates by mosquito larvae. Similarly, lower water temperatures reduce the feeding rate of mosquito larvae and, therefore, may result in a longer persistence of the solid and granule formulations (Maine Department of Environmental Protection 2010).

Toxins produced by Bti degrade rapidly in sunlight as a result of exposure to ultraviolet radiation. Persistence of Bti is low in the environment, usually lasting 1 to 4-days due to sensitivity to UV light. The δ-endotoxins produced by Bti degrade by soil microorganisms with soil half-lives of 3 to 6 days. The bacterium is moderately persistent in soil with a half-life of 4-months. Bti, as with other soil microbes, does not percolate through the soil and readily binds to sediments within the water column, and is, therefore, not available to contaminate ground water (Maine Department of Environmental Protection 2010).

4.3.2.2 Human Toxicity

No known mammalian health effects have been demonstrated in any infectivity/pathogenicity study. Studies for acute oral toxicity have found no adverse toxic effects, infectivity, or pathogenicity at doses up to $4.7x10^{11}$ spores/kg. Studies on acute pulmonary toxicity have found no adverse toxic effects, infectivity, or pathogenicity at doses up to $2.6x10^{7}$ spores/kg. Studies on acute intraperitoneal toxicity have found Bti to be nontoxic at dose levels below 10^{8} CFU per animal (USEPA 1998g).

4.3.2.3 Ecological Toxicity

Due to the relatively short insecticidal half-life of Bti spores and crystals, the exposure and subsequent risk to non-target wildlife is limited to the time immediately after application. Toxicity and infectivity risks due to δ-endotoxins effects to non-target avian, freshwater fish, freshwater aquatic invertebrates, estuarine and marine animals, arthropod predators/parasites, honey bees, annelids and mammalian wildlife will be minimal to nonexistent at the label use rates of registered Bti active ingredients. Bti δ-endotoxin has a direct adverse effect on the target insect orders (*Lepidoptera, Coleoptera, Diptera*), but susceptibility varies widely among individual species. Any one registered product has a narrow susceptible insect range (USEPA 1998g).

The amount of toxins contained within Bti products is reported indirectly as the result of at least two different bioassays, and is difficult to equate to one another. Prepared volumes of toxins are applied to living mosquito larvae and the resulting mortality produces through formulae numerical measures known as International Toxic Units (ITUs) and *Ae. aegypti* International Toxic Units (AA-ITUs). These measures are only roughly related to observed efficacy in the field, and are therefore inappropriate to consolidate and report on like other toxicants (active ingredients). There is currently no chemical test that will differentiate Bti mosquito control products from other spore forming bacilli existing in the environment.

Bti applied at label rates has virtually no adverse effects on applicators, livestock, or wildlife, including beneficial insects, annelid worms, flatworms, crustaceans, mollusks, fish, amphibians, reptiles, birds, or mammals (Garcia et al. 1981, Holck and Meek 1987, Gharib and Hilsenhoff 1988, Miura et al. 1980, Mulla et al. 1982, Reish et al. 1985, Siegel and Shadduck 1987, Knepper and Walker 1989, Merritt et al. 1989, Tietze et al. 1991, Molloy 1992, Tietze et al. 1992, Tietze et al. 1993, La Clair et al. 1998). However, non-target activity on larvae of some insect species closely related to mosquitoes and found with mosquito larvae in aquatic habitats has been observed. There have been reported impacts in larvae belonging to the midge families Chironomidae, Ceratopogonidae, and Dixidae (Mulla et al. 1990, Molloy 1992, Anderson et al. 1996). These non-target insect species, taxonomically closely related to mosquitoes and black flies, apparently contain the necessary gut pH and enzymes to activate delta-endotoxins. However, the concentration of Bti required to cause these effects is 10 to 1,000 times higher than maximum allowed label rates for mosquito control.

Bacterial spores of Bti are uniquely toxic to nematoceran Diptera (mosquitoes, midges, blackflies, psychodids, and ceratopogonids) (Lacey and Mulla 1990). That result was reported after reviewing Bti studies conducted using a variety of Bti formulations, and under a variety of test conditions. Lacey and

Mulla (1990) concluded that Bti was a highly selective larvicide that produced minimal adverse impact on the environment. Garcia et al. (1981) tested a total of 23 species of aquatic organisms other than mosquito larvae using various formulations of Bti in his laboratory. No mortality was observed for these species with the exception of *Chironomus maturus* and a *Simulium* sp. (black fly), which showed a degree of susceptibility similar to that of mosquito larvae. Miura et al. (1980) found Bti at rates used for mosquito control to be very safe to organisms associated with mosquito breeding habitats. A total of 28 species or species groups were treated with the bacterium under simulated or field conditions, with no adverse effects observed, except for chironomid larvae, which were slightly affected. However, the effect was so light that the population in the field continuously increased after the treatment. Miura et al. (1981) found Bti and Bs, when applied at rates used for mosquito control, was very safe to organisms associated with mosquito breeding habitats, including the natural enemies of mosquito larvae. When various aquatic organisms were exposed to the bacteria under laboratory or field conditions, no adverse effect was noted on the organisms, with the exceptions of chironomid and psychodid larvae. Chironomid larvae were slightly affected by Bti treatment at a rate used for mosquito control, but pyschodid larvae were only affected at the higher concentration (50 mg/L).

Exposure of brook trout (*Salvelinus fontinalis)* fry to 4,500 and 6,000 milligrams per liter (mg/L) Teknar (a liquid formulation of Bti) (more than 50 times the allowed label rate for mosquito control) for 45 minutes resulted in 20 and 86.4-percent mortality, respectively (Fortin et al. 1986). Some species of chironomids are also susceptible to Bti, but at doses much higher than those used to control mosquito larvae (Mulla et al., 1990). Bti has been used extensively for control of mosquitoes in Germany without affecting populations of chironomids (Becker and Margalit 1993)

A number of Bti fermentation-based products tested at high-dose levels have shown intrinsic toxicity to non-target organisms. Investigations conducted to determine the source of the non-target activity have implicated heat-labile soluble substances contaminating the technical material. Toxic effects have been seen in aquatic invertebrate *Daphnia magna*, the honeybee, some beneficial insects and fish (rainbow trout, bluegill) studies, with Daphnia being the most sensitive indicator of toxicity. The impurities are found in the supernatant fluids separate from the delta-endotoxins. The toxicity does not appear to be due to the heat-stable β-exotoxin, because autoclaving of the test material renders the supernatant fluids innocuous. The heat-labile, soluble toxic impurities have thus far been seen in Bt subspecies *kurstaki*, *aizawai*, and *israelensis*, but may possibly be present in other Bt varieties. Damgaard (1995) reported varying levels of at least one soluble exotoxin in all commercial Bti products tested (Damgaard 1995). Bt subspecies *aizawai*-based products show the greatest negative effects on non-target organisms. With Bt subspecies *kurstaki*, the manifestation of the toxin(s) appears to be at least partly related to production methodology, especially the composition of the growth media used in industrial fermentation. In response to concerns, the manufacturer of VectoBac has completed continuous 10-day exposure tests on *Daphnia magna* with the active ingredients found in VectoBac products (fermentation solids and solubles produced by *Bti* strain AM65-52). Results indicated that the LC50 is higher than 50 mg/L for *Daphnia magna* when exposed continuously for 10 days. Based on maximum label rates of VectoBac products, expected environmental concentrations (EEC) of active ingredients do not exceed 1 mg/L immediately following application, based on a conservative assumption of a water depth of 10 cm. Therefore, application of VectoBac at label rates will not result in active ingredient concentrations approaching 10 percent of the LC50 for *Daphnia magna* (DeChant 2010).

Evidence indicates that some species of chironomid larvae (which are closely related to mosquitoes) are the only non-target aquatic species that may be affected at concentrations of Bti used for mosquito control. Observed effects on chironomids were slight and populations in the field continuously increased after the treatment.

4.3.2.4 Summary of Toxicity and Potential Effects

Bti is an effective microbial pesticide specifically targeted at mosquito larvae. Bti is a natural enemy of mosquito larvae and, therefore does not pose risk to non-target organisms, including humans and ecological receptors. This microbial larvicide is used by eight of the districts, typically throughout the year (all quarters during the reporting year). Bti is contained in 12 products used by the Districts during the reporting year. Proper PPE is used during handling, loading, and applying of the liquid form of Bti. Bti is an important component of any IPM program for mosquito larvae control.

It is important to distinguish this subspecies from Bt, which is frequently used in corn. In addition, Bti is a microbial gut toxin product and not a "live" bacterium. Bti is considered one of the safest natural forms of mosquito control.

In addition to the toxicity values referenced in Sections 4.3.2.2 and 4.3.2.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.3.3 Spinosad

Spinosad was first registered for use in California in 1996 for use as an agricultural insecticide, and more recently, registration has been approved for the use of mosquito control in California in areas such as dormant rice fields, wastewater, and temporary standing water (CDPR 2010b). Spinosad is used on a variety of crops, ornamental plants, greenhouses, ornamental lawns, and gardens; rangeland, pastures, animal husbandry premises, dairy barns, silos, and cattle; industrial sites, cracks and crevices, rights-of-way, recreation areas, golf courses, outdoor buildings and structures, and household or domestic dwellings (CDPR 2010a).

Spinosad is a biologically derived insecticide produced from the fermentation of *Saccharopolyspora spinosa*, a naturally occurring soil organism. Spinosad is a mixture of spinosyn A and spinosyn D; commercial formulations contain a spinosyn A to spinosyn D ratio of approximately 85:15. Spinosad activates the central nervous system of insects through interaction with neuro-receptors and causes continuous stimulation of the insect nervous system (Kollman 2002, Clarke Mosquito Control 2009). The EPA has classified spinosad as a "reduced risk" compound because it is an alternative to more toxic, organophosphate insecticides (CDPR 2002).

4.3.3.1 Environmental Fate

The routes of spinosad dissipation and transformation in the environment include photodegradation and biotransformation on plant surfaces, aqueous photolysis, photodegradation on soil, and biotransformation via soil microorganisms (Table 4-14). Aqueous photolysis is rapid in natural sunlight, and is the primary route of degradation in aquatic systems exposed to sunlight. In the soil environment, spinosad adsorbs strongly to soil particles and is unlikely to leach to great depths. It is photodegraded quickly on soil exposed to sunlight, but the degradation rate is decreased at longer exposure times. Spinosad is quickly metabolized by soil microorganisms under aerobic condition. Under anaerobic conditions, the degradation rate is slower (Kollman 2002). Photolysis results in degradates that are orders of magnitude less toxic than Spinosad.

Table 4-14 Degradation of Spinosad

Degradation Method	Half-life	Reference
Hydrolysis, pH 7-9 (water)	Stable	Kollman 2002
Photolysis (water)	0.84 to 0.96 Day	Kollman 2002
Photolysis (soil)	8.68 to 9.44-Days	Kollman 2002

Table 4-14 Degradation of Spinosad

Degradation Method	Half-life	Reference
Aerobic metabolism (soil)	14.5 to 17.3 Days	Kollman 2002
Anaerobic metabolism (soil)	161 to 250 Days	Kollman 2002

4.3.3.2 Human Toxicity

Spinosad is of low acute toxicity by all exposure routes. The oral LD50 for rats is >5,000 mg/kg. The dermal LD50 for rabbits is >2,800 mg/kg. The inhalation LC50 for rats is >5.18 mg/L (USDA 1999, Table 6-1). There has been no evidence of mutagenic or carcinogenic effects in chronic studies.

4.3.3.3 Environmental Toxicity

Spinosad is slightly to moderately toxic to fish and most aquatic invertebrates (USDA 1999). Acute LC50 values for bluegill and sheepshead minnow are greater than 5,000 µg/L and 7,000 µg/L, respectively, and the chronic NOAEC values for trout and sheepshead minnow are both greater than 1,000 µg/L (Goudie 2010). Hertlein et al. (2010) stated that no negative impacts were observed for individual mosquito fish held in water containing up to 50,000 µg/L of spinosad. This material also has low acute toxicity for fresh and saltwater invertebrates, with an acute EC 50 of greater than 10,000 µg/L for daphnia (Goudie 2010). The acute EC50 for oysters was greater than 300 µg/L (Goudie 2010). Laboratory studies demonstrate some toxicity for some aquatic invertebrates under chronic exposure, but residues dissipate rapidly and are rapidly degraded by photolysis with a half-life in water of less than half a day (Goudie 2010). Stark and Vargas (2003) reported a decline in *Daphnia pulex* when exposed to Spinosad in the laboratory. However, the organisms were held in a continuous renewal system, with fresh Spinosad added every 24 hours. Mortality also occurred in daphnia held in plexiglass enclosures at a field site during applications of Spinosad (Duchet et al. 2008). However, mortality occurred immediately after the applications and the authors also noted that the Spinosad dissipated rapidly from the water column and was detected at 4 to 13 percent of the initial concentrations (8 to 33 µg/L) in water 4-days after its application (Duchet et al. 2008). Hertlein et al. (2010), reporting an unpublished study by Laddoni (2006, no citation available) noted slight impacts on nonmosquito insects (*Dyticsidae, Histeridae, Libellulidae, Notonectidae*) were observed in an artificial pond treated with 50 ppb or 50 g/ha of spinosad. However, this is above field use rates and the authors concluded that Spinosad was minimally disruptive to non-targets when applied near field use rates (15 to 25 ppb).

Spinosad is practically nontoxic to birds. The acute oral LD50 for bobwhite quail and mallard ducks is >2,000 mg/kg (MacBean 2012, USDA 1999).

While high doses and/or chronic exposure of Spinosad may adversely affect some aquatic invertebrates, the short-term exposure at levels used for mosquito control is unlikely to have unwanted effects.

4.3.3.4 Summary of Toxicity and Potential Effects

Spinosad readily degrades by a number of chemical and biological processes and is not environmentally persistent. Although toxicity is low to mammals, fish, invertebrates, and birds, non-target insects (e.g., some species of moths and butterflies) could be at risk. However, low amounts typically used for mosquito control would not likely pose a significant risk to potential ecological receptors.

Spinosad is used by four of the Districts throughout the year, including during each quarter of the reporting year. It is applied in three different products (0.5 to 20 percent Spinosad) to standing and moving water in natural and anthropogenic sites. These products were applied several thousand times throughout the reporting year.

Based on the environmental fate, human and ecological toxicity, and usage patterns, using BMP application practices, spinosad should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Sections 4.3.3.2 and 4.3.3.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.3.4 Methoprene and s-Methoprene

Methoprene is a long chain hydrocarbon ester classified as an insect growth regulator and selective larvicide. Methoprene consists of two enantiomers: S-methoprene and R-methoprene. S-methoprene is the biologically active enantiomer in the racemic compound (FAO-WHO 2005). Fate and transport characteristics of the s-enantiomer and the mixture are similar, but toxicity differs. Methoprene is used principally against mosquitoes, but is effective against a range of insects, including the orders Diptera, Lepidoptera and Coleoptera. Methoprene is an insect growth regulator that interferes with the normal maturation process of insects, preventing them from completing their life cycle and reaching adulthood, thus ultimately preventing them from reproduction (Csondes 2004).

Methoprene was first registered by the EPA in 1975 (USEPA 1991e). Methoprene is used indoors and outdoors at domestic dwellings, in flea and tick treatments for cats and dogs, for crack and crevice treatments, and on outdoor buildings and structures, recreation areas, swimming pools, golf courses, ornamental lawns, ornamental ponds, and shrubs. Methoprene is used at animal husbandry premises, on cattle, barnyards, rangeland, pastures, fallow land, and in animal drinking water. It is used at industrial sites, on highway rights-of-way, industrial waste disposal systems, industrial/commercial ponds, wastewater, and bilge water. Methoprene can be applied to irrigation systems, orchards, crops, berries, fruit trees, and rice. It is also used in drainage systems, swamps, marshes, intermittently flooded areas, catch basins, polluted stagnant water, sewage systems, and applied by mosquito abatement Districts (CDPR 2010a).

Methoprene products used in mosquito control are applied as briquets, pellets, sand granules, and liquids. The liquid and pelletized formulations can be applied by helicopter and fixed-wing aircraft or ground-based equipment. Methoprene is applied either in response to observed high populations of mosquito larvae at a site, or as a sustained-release product that can persist for 4-months or longer if a site has limited accessibility, limited flushing and water outflow, and has regularly produced immature mosquitoes in the past.

4.3.4.1 Environmental Fate

When methoprene is released into water, it sorbs to suspended solids and sediments. When applied to soil, methoprene is relatively immobile, tending to reside in the top few centimeters of the soil (Csondes 2004). Methoprene (and s-methoprene) is a very short-lived material in nature (Table 4-15). It rapidly degrades in aqueous solution and on inert surfaces by photolysis. It is metabolized in soil under both aerobic and anaerobic conditions. Degradation in the aquatic environment is due to both microbial metabolism and photolysis (USEPA 1991e).

Table 4-15 Degradation of Methoprene/s-Methoprene

Degradation Method	Half-life	Reference
Hydrolysis (water)	Stable	FAO-WHO 2005
Photolysis (thin film)	6 Hours	FAO-WHO 2005
Photolysis (water/sediment system)	<1 Day	FAO-WHO 2005
Aerobic metabolism (pond water)	30 to 40 Hours	FAO-WHO 2005
Aerobic metabolism (soil)	10 Days	FAO-WHO 2005; USEPA 1991e

Table 4-15 Degradation of Methoprene/s-Methoprene

Degradation Method	Half-life	Reference
Anaerobic metabolism (soil)	14 Days	USEPA 1991e
Field dissipation (pond water)	13 Days	Csondes 2004

4.3.4.2 Human Toxicity

Methoprene is of very low acute toxicity by all routes (USEPA 1991c). The oral LD50 for rats is >10,000 mg/kg. The dermal LD50 for rabbits is >2,000 mg/kg. The inhalation LC50 for rats is >210 mg/L (USEPA 1991c, 2001) (Table 6-1).

4.3.4.3 Ecological Toxicity

Methoprene is practically nontoxic to birds. The oral LD50 for mallard ducks is >2,000 mg/kg. It is moderately toxic to freshwater fish. The 96-hr LC50 for bluegill sunfish is 1.52 µg/L. Methoprene is highly toxic to aquatic invertebrates. The 48-hr EC50 of technical methoprene for *Daphnia magna* is 89 µg/L (USEPA 1991c).

Methoprene is applied at very low concentrations for mosquito control. The manufacturer has developed a number of formulations to maintain an effective level of the active material in the mosquito habitat (0.5 to 3.0 parts per billion [ppb]; (Scientific Peer Review Panel 1996) for a practical duration, thus minimizing the cost and potential impacts associated with high-frequency repeat applications. Rate of release and data generated under laboratory and field conditions with methoprene mosquito product formulations, including slow release briquet formulations, indicate a maximal rate of release of ≤4-ppb (USEPA 2001). Ross et al. (1994) conducted microcosm studies, which applied 5 sustained release methoprene formulations at maximum label application rates to tanks containing water 6 inches deep. Methoprene concentrations were measured 1, 2, 4, 7, 14, 21, 28, and 35 days after treatment, and the highest resulting microcosm methoprene concentration measured was 6 ppb.

Exhaustive reviews of the published literature on this material attest to its lack of adverse environmental impact (Mian and Mulla 1992, Scientific Peer Review Panel 1996, Glare and O'Callaghan 1999, State of Minnesota 1999, USEPA 2001). The acute, short-term toxicity of ZR-515 (methoprene) was also tested on 35 aquatic organisms, including Protozoa, Platyhelminths, Rotatoria, Annelida, Arthropoda, Mollusca, Chordata and Thallophyta, and LC50 values of 0.9 to 5.0 mg/L were calculated (250 to 1,000 times label rates) (Miura and Takahashi 1973). Dosages used for larval mosquito control produced no adverse effect on the organisms tested, except for some sensitivity in the aquatic Diptera (flies) in the families Chironomidae, Ephydridae, and Psychodidae.

Bircher and Ruber (1988) assessed the toxicity of methoprene to all lifecycle stages of the salt marsh copepod (*Apocyclops spartinus*) at concentrations ranging from 100 to 10,000 µg/L. In general, the copepods were resistant to concentrations of methoprene used to control mosquitoes, but early larval stages did show some mortalities in the test series. The calculated 48-hr LC50, adjusted for control mortality, was 800 µg/L which is about 400 times greater than the typical application rate. Christiansen et al. (1977) showed a reduction in survival of larvae of the mud-crab *Rhithropanopeus harrisii* (Gould) in the laboratory under a range of salinity and temperature conditions, when exposed to 10, 100, and 1,000 µg/L methoprene, levels 5 to 500 times field application rates. McKenney and Mathews (1988) reported that larval survival, growth, and energy metabolism of an estuarine shrimp *Palaemonetes pugio* were altered by exposure to 100 µg/L of methoprene (50 times greater than application rates). However, Wirth et al. (2001) reported no observed differences in the percent successfully hatching or larval mortality 3 days post hatch in *P. pugio* exposed for 96 hours to 1,000 µg/L. In addition, in 2004, Suffolk County conducted 4-day static renewal toxicity tests on grass shrimp (*Palaemonetes pugio*) using water collected

30 minutes after aerial application of methoprene for mosquito control and observed no toxicity (Turner et al., 2006). Similar investigations have been carried out with *Leander tenuicornis*, an estuary shrimp that occurs in Australian intertidal marshes. Methoprene was nontoxic at field application levels in 96-hour toxicity tests (Brown et al. 1996). The LC50 of methoprene for *L tenuicornis* (14,320 µg/L) in these tests was 1,790 times field concentrations when applied at label rates. The authors concluded that methoprene could be safely applied in situations where the shrimp were present and that no mortality of shrimp was likely at the levels applied for mosquito control. Further laboratory work (Brown et al. 2000) found that the dose lethal to mosquitoes (*Culex annulirostris*) was 3,000 times below the LC_{95} for shrimp (*Caradina indistincta)*. Zulkosky et al. (2005) investigated the potential effect of methoprene runoff to larval lobsters (*Homarus americanus*) in continuous flow-through systems for 48 hours: methoprene was not toxic at the highest concentration tested (10 micrograms per liter [µg/L] or 10 µg/L). Laboratory studies with fish demonstrated that methoprene had no effect on the survival of adult and juvenile rainbowfish (*Melanotaenia duboulayi*) (Brown et al. 2002). No effect was observed on swimming performance of rainbowfish when exposed to up to ten times effective field concentrations of applications made for mosquito control (Hurst et al. 2007).

Methoprene studies have not shown adverse effects on amphibians. Tests conducted on various life stages of different amphibian species (*Bufo woodhousei*, *Rana catesbeiana* and *Rana pipiens*) found no adverse effects from acute or chronic exposures at the highest dose tested. Acute studies on *R. catesbeiana* and *R. pipiens* larvae indicate LC50 values >10,000 µg/L and *B. woodhousei* adult LC50 values >1,000 µg/L (highest dose tested). Chronic studies on *B. woodhousei* indicate a 22-day LC50 >1,000 µg/L and LC50 >1,000 µg/L for *R. catesbeiana* and *R. pipiens* (USEPA 2001).

One early field study assessing applications of technical (pure powdered) methoprene on a Louisiana coastal marsh yielded ambiguous results (Breaud et al. 1977). Highly significant declines were observed in the occurrence of 14-invertebrates immediately following the application, including selected life stages and species of amphipods, shrimp, mayflies, dance flies, midges, freshwater snails, damselflies and dragonflies, and water beetles. However, the abundance of five other invertebrates significantly increased including water boatmen, moth flies, two species of crawfish, and predaceous diving beetles. No statistically significant difference was seen between the test and control populations of another 28 aquatic organisms. Interpretation of this study is difficult in part because of the mixed nature of the results, which may simply indicate the complexity of ecosystem dynamics in marshlands. Also, the application rate (28 gm active ingredient/ha technical powder) was at least twice the highest label rate of active ingredient allowed today, and was effectively much higher when the encapsulation and other coatings on modern formulations are considered. The relevance of Breaud et al.'s entire experiment as a legitimate field study may be called into question, as the properties of technical grade methoprene powder render it unfit for any type of direct field application under current label restrictions.

Since the publication of Breaud et al. (1977), there have been numerous field studies using currently available mosquito control products containing methoprene, in which no detectable effect was observed in aquatic invertebrates. For example, no detectable mortality occurred in Talitrid amphipods exposed to aerial applications of Altosid to a Florida mangrove swamp in 1999 (Lawler et al. 1999). A similar study assessed applications of a sustained release formulation of methoprene and a combined liquid formulation of *Bti* and methoprene (duplex) to tidal wetlands of San Francisco Bay. No difference was seen in growth or development of water boatman, and no difference in the number of non-target insects inhabiting treated versus untreated plots (Lawler et al. 2000). The authors also monitored brine flies at treated and untreated sites using sentinel cages, and sampled populations with sweep nets. No decline was observed in flies relative to controls collected by sweep nets. Caging of sentinels was unsuccessful at assessing impacts, since none of the caged flies survived at untreated sites or treated ones.

Aerial applications of liquid methoprene on saltmarsh habitat have also been assessed in Australia (Russell et al. 2009). Changes in assemblages of invertebrates through time were observed in both treated and untreated (control) plots. No significant effects were seen on arthropods in ephemeral pools.

There was no significant difference in abundance of nonmosquito dipterans (flies), heteropterans (true bugs), and hymenopterans (primarily ants) in treated versus untreated sites. Some differences were observed in copepod populations during the treatment period, but these were short-term or inconsistent between localities or between sampling method. The authors concluded that applications of *Bti* and methoprene to salt marshes do not affect the structure or composition of assemblages of non-target arthropods (Russell et al. 2009).

Published studies on non-target impacts of methoprene for mosquito control were reviewed recently (Davis 2007, Davis and Peterson 2008). The authors also carried out an ecological risk evaluation of mosquito larvicides in a series of ponds at the Benton Lakes National Wildlife Refuge in Montana. *Bti* and methoprene were applied directly to water as liquids, and aquatic arthropods were sampled following the applications. No overall treatment effects were observed on aquatic non-target invertebrates collected in D-shaped net samples. A linear model was then fitted to each of the response variables to determine multivariate treatment effects. Data indicated a possible acute impact on amphipods immediately following application, but no significant effect at 7 to 28 days. No trend was seen across dependent groups of non-target organisms, and there were no persistent biological effects.

Careful review of these and other studies, and the recent reviewers listed above leads to the conclusion that: 1) applications of methoprene (especially technical powder) at rates significantly higher than allowed by the label can adversely impact a number of aquatic animals; 2) animal species are not extirpated (locally eliminated) by repeated methoprene use except at application rates far higher than those used and allowed for mosquito control; 3) emergence of adults of some fly species (specifically, some types of midges) can be temporarily reduced at application rates similar to those used for mosquito control; 4) larval flies affected by methoprene are not killed at label application rates, but are prevented from becoming adults; 5) for species that are affected by methoprene, recolonization and reestablishment of populations from neighboring sites is fast once intense control was relaxed; 6) the patchy distribution of mosquito larvae leads to maintenance of untreated refugia for non-targets, speeding recolonization; and 7) no bioaccumulation of methoprene has been seen in animals that have eaten mosquito or midge larvae treated with methoprene.

The concentrations of methoprene applied for mosquito larvae control are unlikely to affect non-target aquatic species, except for some fly species closely related to mosquitos. For species that are affected by methoprene, recolonization and reestablishment of populations from neighboring sites is fast once intense control is relaxed.

4.3.4.4 Summary of Toxicity and Potential Effects

Methoprene readily degrades in soil and water by a variety of processes. It may exhibit toxicity to fish and aquatic invertebrates, as well as non-target insects including moths, butterflies, and beetles, but these concentrations are much higher than would be experienced in the application scenarios currently in use.

Methoprene is longer-lasting than some of the other larvicides on the market and, therefore requires fewer applications of low amounts. Methoprene is effective at much lower concentrations than alternative larvicide products, which correlates with reduced acute exposures to non-target organisms, as well as potential effects to a lower diversity of midges and chironomids. Extended release forms including granular and briquette varieties are also available, including 30 and 90-day briquettes. This product may be more residual in the environment, however, the methoprene active ingredient in this formulation has a short half-life in water and does not migrate through soil, significantly reducing the potential for groundwater impacts.

Considered the safest of all larvicide alternatives, methoprene is used prevalently by the nine Districts during each season, including all four quarters of the reporting year. There are 12 methoprene-containing products (0.2 to 8.62 percent methoprene) that are applied to natural and anthropogenic standing and moving water bodies. Many of these products are Altosid formulations (Wellmark) and one is MetaLarv SP-T (see Table 3-1). These products were applied several thousand times during the reporting year.

Liquid and granular forms are most prevalently used in residential and ornamental pond application scenarios. Treatments to wetlands including marshes require the granular form (e.g. Altosid XRG with *Bacillus sphaericus*) to penetrate dense aquatic vegetation including cattails and tules. Methoprene is also sometimes co-applied with Bti. Drift is almost irrelevant for hand and aerial (e.g., helicopter) applications since treatments are restricted at moderate to high wind speeds. Methoprene is highly effective against mosquitoes at low concentrations and degrades quickly in the environment, thereby reducing the potential exposure and risk to non-target organisms. When handled and applied using appropriate BMPs, methoprene is one of the safest (human and ecological) and most effective mosquito control products used by the Districts. Based on toxicity, environmental fate, and usage patterns, methoprene, using BMPs is not likely to result in unwanted adverse impacts.

In addition to the toxicity values referenced in Sections 4.3.4.2 and 4.3.4.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.3.5 Alcohol Ethoxylated Surfactant (Monomolecular Film)

The monomolecular film used in California for the control of mosquito larvae is alpha-isooctadecyl-omega-hydroxypoly (oxyethylene). Agnique is the trade name for this recently reissued surface film larvicide. Monomolecular films are alcohol ethoxylated surfactants, which are low-toxicity pesticides that spread a thin film on the surface of the water that makes it difficult for mosquito larvae, pupae, and emerging adults to attach to the water's surface, and cause them to drown (USEPA 2007c). It also disrupts respiration of some other classes of air-breathing aquatic insects.

Monomolecular films are used on ornamental ponds, pastures, irrigation systems, drainage systems, drinking water systems, intermittently flooded areas, catch basins, lakes, ponds, reservoirs, tidal areas, marshes, and standing water, industrial waste disposal systems, polluted and stagnant water, and sewage systems (CDPR 2010a).

4.3.5.1 Environmental Fate

Reported half-lives of monomolecular films in water range from 5 to 22 days and Agnique has an average persistence in the environment of 5 to 21 days at label application rates (Oester 2010).

4.3.5.2 Human Toxicity

Because of the mode of action and likely exposure scenarios of these products, there is little to no indication of potential for adverse effects to humans.

4.3.5.3 Ecological Toxicity

A number of efficacy and non-target studies had been conducted on this material when it was registered under the name Aerosurf. Minor proprietary changes in preparation did not apparently change any of the material's potential environmental impacts; therefore, the earlier literature is referenced.

Most published studies conducted with this larvicide tested application rates of 3 to 100 times the maximum label rate. At these rates, no observable effect on mortality or development was noted in tests on green tree frogs, seven species of fresh and salt water fish, two species of shrimp, five species of water beetle, or one species each of fairy shrimp, crayfish, snail, polychaete worm, mayfly naiad, copepod, ostracod, or midge. In addition, no effect was seen on five species of plants. Air (surface) breathing insects were temporarily adversely impacted. Water boatmen, backswimmers, and one species of water beetle exhibited increased mortality at application rates above label limits. In addition, a clam shrimp, a crab, an amphipod, and one species of isopod exhibited minor to significant increases in mortality at levels several times the highest application rate allowed by the label (Oester 2010).

Although evidence indicates that application of monomolecular films and petroleum distillates may result in reductions to populations of surface-breathing insects at the time of treatment, it is unlikely that overall populations of invertebrate species are affected as populations recover quickly due to recolonization from neighboring sites.

4.3.5.4 Summary of Toxicity and Potential Effects

Alcohol ethoxylated surfactants exert no lasting or observable effect on most non-target organisms, so that using BMP application practices, these chemicals should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Sections 4.3.5.2 and 4.3.5.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.3.6 Aliphatic Solvents (Mineral Oils and Aliphatic Petroleum Hydrocarbons)

Specially-derived aliphatic solvents (e.g., mineral oils and aliphatic petroleum hydrocarbons such as GB-1111 and BVA-2) are used to form a coating on top of water to drown larvae, pupae, and emerging adult mosquitoes. These products of petroleum distillation processes have been used for many years nationwide to kill aphids on crops and orchard trees, and to control mosquitoes (USEPA 2007d). They are applied to a wide variety of crops, trees and ornamental plants; to swamps, marshes and intermittently flooded areas. These compounds are also used as an adjuvant for pesticides to increase efficacy and/or application efficiency. These compounds, with appropriate BMPs are applied by mosquito abatement districts (CDPR 2010a). Dormant oils are widely used in the Central Valley on tree crops.

CocoBear Mosquito Larvicide Oil is a plant based oil (also see Section 4.7.3). This product consists mostly of a modified coconut oil (75 percent or more by volume) combined with 10 percent by volume mineral oil and a very small amount of nonionic surfactant and other proprietary ingredients. This material can be used in various waterbodies such as ditches, stagnant pools, swamps, marshes, temporary rainwater pools and intermittently flooded areas, ponds, catch basins and manmade containers for the management of immature mosquitoes.

4.3.6.1 Environmental Fate

Petroleum distillates are effective in many situations in which monomolecular films do not give sufficient control. These materials also break down much more rapidly than monomolecular films (2 to 3 days as opposed to 21 days), which decreases their impact to non-target organisms.

4.3.6.2 Human Toxicity

These chemicals have a low degree of acute toxicity to mammals. There was no mortality in rats at an acute oral dose of 28,000 mg/kg bw. They are virtually nontoxic via dermal and inhalation routes (USEPA 2007d) (Table 6-1).

4.3.6.3 Ecological Toxicity

The safety of petroleum distillates for non-targets has been demonstrated by both laboratory and field studies. Three studies (Tietze et al. 1991, Tietze et al. 1992, Tietze et al. 1994) tested three species of fish (Inland Silversides, Mosquitofish, and Sheepshead Minnows), and a range of microorganisms and concluded that petroleum distillate formulation GB-1111 is not toxic to the tested organisms at label application rates. Mulla and Darwazeh (1981) tested GB-1111 in small experimental ponds and found that benthic invertebrates (including mayflies, dragonflies, and damselflies) were unaffected, while populations of surface-breathing insects were temporarily reduced, following application of this larvicide. Miles et al. (2002) completed an independent study of non-target effects of GB-1111, with financial assistance from the U.S. Fish and Wildlife Service (USFWS), on the tidal marshes of the Don Edwards National Wildlife

Refuge in San Francisco Bay near Newark, California, and observed the following effects: 1) surface-breathing insect populations were reduced at the time of treatment; 2) this effect did not persist beyond a few days (no residual pesticide effects); 3) those potentially affected animals with high mobility left the site, while some of those that could not leave died (especially water boatmen [*Corixidae*]); and 4) overall populations of invertebrate species were not affected, apparently because of recolonization from neighboring untreated sites.

Although evidence indicates that application of monomolecular films and petroleum distillates may result in reductions to populations of surface-breathing insects at the time of treatment, it is unlikely that overall populations of invertebrate species are affected as populations recover quickly due to recolonization from neighboring sites.

4.3.6.4 Summary of Toxicity and Potential Effects

Aliphatic solvents have very low water solubility and high sorption to organic matter. They are practically nontoxic to most non-target organisms and rapidly break down in the environment, reducing their impact on susceptible non-targets so that, using BMP application practices, these products should not result in unwanted adverse effects. These products are used for both mosquito control and adjuvants to some pesticides to increase or improve efficacy and/or application efficiency. Golden bear and BVA-2 oils are pesticides used in controlling immature mosquito populations and is used to suppress mosquito related issues, including suppression of potential West Nile virus. Some white mineral oil based compounds are nontoxic food products and are used in numerous cosmetic products. No general direct toxicity has been reported. When added to other compounds as a surfactant, the toxicity of the primary chemical is the issue but not the oil product. A recent development is the use of plant based food grade oils such as coconut oil that is combined with a small amount of mineral oil (e.g. CoCoBear Oil) CoCoBear has no reported significant toxicity to any receptors likely to be exposed during or after use as a larvicide. Acute oral toxicity to rats is >5000 mg/kg, acute dermal toxicity to rats is > 5050 mg/kg, and acute inhalation toxicity to rats is > 2.16 mg/L (Clarke 2014).

Therefore, the Districts rely on toxicology data for mineral oil as well as the product formulation, and this is reflected accordingly in the data found in Table 6-1. In addition to the toxicity values referenced in Sections 4.3.6.2 and 4.3.6.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.4 Other Insecticides

4.4.1 Potassium Salts

Potassium salts of fatty acids are used as insecticides, acaricides, herbicides and algaecides. They are used to control a variety of insects and mosses, algae, lichens, liverworts and other weeds, in or on many food and feed crops, ornamental flower beds, house plants, trees, shrubs, walks and driveways, and on dogs and cats. Potassium salts of fatty acids include potassium laureate, potassium myristate, potassium oleate, and potassium ricinoleate. Once applied, however, these salts are degraded quickly in soil by microbes, and do not persist in the environment (USEPA 1992).

4.4.1.1 General Toxicity

Commonly referred to as “soap salts”. They are produced by adding potassium hydroxide to fatty acids found in plant or animal oils. Fatty acids are extracted from palm, coconut, olive, castor, and cottonseed plants (National Pesticide Information Center 2001). Fatty acids penetrate an insect’s body covering and disrupt the cell membranes. The insect dies of dehydration. Soft-bodied insects, such as aphids, are more susceptible as are immature insects.

4.4.1.2 Human Toxicity

Soap salts have low oral and dermal toxicity to mammals but may cause general stomach upset in humans. They may be irritating to the skin and eyes (USEPA 1992). These products are generally considered safe by the FDA. The USEPA classifies soap salts as Category IV (lowest level of toxicity) for acute effects (Table 6-1).

4.4.1.3 Ecological Toxicity

Soap salts are practically nontoxic to birds but slightly toxic to fish and highly toxic to aquatic invertebrates (USEPA 1992). Pesticides containing potassium salts of fatty acids are used in a wide array of outdoor sites; however, the compounds degrade very quickly in soil. Because soap salts are not applied directly to water, they pose little threat to sensitive aquatic invertebrates (USEPA 1992).

4.4.1.4 Summary of Toxicity and Potential Effects

Potassium salts degrade quickly in the environment. They are of low toxicity to birds and mammals, but highly toxic to fish aquatic non-target invertebrates. The Districts did not use potassium salt products during the reporting year; therefore, when needed, using BMP application practices, these products should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Sections 4.4.1.2 and 4.4.1.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.5 Rodenticides

These chemicals are for the control of mammal pests, particularly commensal rats and mice (e.g., Norway rat, roof rat, and house mouse) but also a variety of field rodents.

The anticoagulant rodenticides are typically grouped into “first-generation” (e.g., chlorophacinone, diphacinone) and “second-generation” (e.g., brodifacoum, bromadiolone, difethialone) compounds. Second-generation anticoagulants tend to be more acutely toxic than are the first-generation anticoagulants, and they are retained much longer in body tissues of primary consumers. In contrast, the first-generation compounds are less acutely toxic and more rapidly metabolized and/or excreted (USEPA 1998e). Both classes have the same mode of action but second generation anticoagulants have a significantly longer liver half-life than first generation anticoagulants (USEPA 1998e).

4.5.1 Chlorophacinone

Chlorophacinone is used to control a variety of vertebrate pests, mainly rodents, but also jackrabbits (lagomorphs), and moles (insectivores). It is a first-generation anticoagulant and is formulated as tracking powder, as loose-grain bait, paraffinized pellets, rat and mouse bait ready-to-use place packs, and paraffin blocks. Chlorophacinone is currently registered for the control of rodents in and around buildings, households and domestic dwellings, uncultivated agricultural and nonagricultural areas, commercial transportation facilities; industrial areas, and food processing, handling, and storage areas and facilities. Both general use and restricted use chlorophacinone products are currently registered (USEPA 1998e).

4.5.1.1 Environmental Fate

Chlorophacinone is readily degradable by photolysis in the environment. It has low water solubility, is very susceptible to direct photolysis in water and is moderately susceptible to photodegradation on soil (Table 4-16; USEPA, 1998e). Chlorophacinone volatilizes slowly from water and soil and degrades slowly by acid hydrolysis with no measurable hydrolysis at higher pHs. Chlorophacinone is considered to be

moderately persistent and immobile in soil. The major route of dissipation in soil appears to be aerobic soil metabolism (USEPA 1998e, Hartless and Jones 2011).

Table 4-16 Degradation of Chlorophacinone

Degradation Method	Half-life	Reference
Hydrolysis, pH 5	232 Days	Hartless & Jones 2011
Hydrolysis, pH 7-9	Stable	USEPA 1998e, Hartless & Jones 2011
Photolysis (water)	37 minutes	USEPA 1998e
Photolysis (soil)	4 Days	USEPA 1998e
Aerobic metabolism (soil)	17 to 47.2 Days	USEPA 1998e, Hartless & Jones 2011

4.5.1.2 Human Toxicity

The USEPA classifies chlorophacinone as Category I (highly toxic) for oral, dermal, and inhalation toxicity to mammals (USEPA 1998e). The oral LD50 of chlorophacinone is 3.15 mg/kg for male rats and 0.329 mg/kg for male rabbits (USEPA 1998e). Human volunteers were able to tolerate a single dose of 20 mg active ingredient with an uneventful recovery and no treatment (EXTOXNET 1985c). The dermal LD50 for rabbits is 200 mg/kg. The inhalation LC50 for male rats is 7.0 µg/L. MacBean (2012) reports additional oral and dermal LD50 values of 6.26 and 0.007 mg/kg respectively, and an inhalation LC50 of 0.0093 mg/L for rats. Chlorophacinone is not known to cause skin or eye irritation (USEPA 1998e) (Table 6-1).

4.5.1.3 Ecological Toxicity

Chlorophacinone is toxic to wildlife and fish. The 96-hr LC50 for rainbow trout is 450 µg/L. The use of food bait (aerial or ground broadcast or hand applied pellets) may present an exposure risk to seed-eating birds (USEPA 1998e). The oral LD50 is 258 mg/kg for bobwhite quail (USEPA 1998e). The oral LD50 for carnivorous mammals, including carnivores (e.g., mountain lions, bobcats, coyotes) is 2.1 to 50 mg/kg (Hosea 2000). Data are lacking to assess potential secondary risks to avian predators and scavengers, which may feed on poisoned rodents. The USEPA presumes high risks to any non-target small mammals. Primary risks to larger mammals are reduced by proper use of bait stations. Secondary risk to predatory mammals such as coyotes has been demonstrated. The USEPA indicates that chlorophacinone poses minimal risk to freshwater organisms (USEPA 1998e) (Table 6-1).

4.5.1.4 Summary of Toxicity and Potential Effects

Chlorophacinone has low water solubility and is moderately persistent in soils. Loose-grain baits may present a risk to non-target foraging animals, including seed-eating birds. This first-generation rodenticide is highly toxic to mammals, including humans, domestic pets, and non-target mammalian wildlife. However, since it is generally applied as solid bait blocks, significant release and environmental impact is not anticipated. In addition, chlorophacinone was not used by the MVCAC Districts during the reporting year. For these reasons, and when needed, using BMP application practices, these products should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Sections 4.5.1.2 and 4.5.1.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District

4.5.2 Diphacinone

Diphacinone and diphacinone salt products are first-generation anticoagulants formulated predominantly as food baits (loose bait, feeder boxes, place packs, or paraffinized bait blocks) for control of commensal rats (Norway rat, roof rat) and mice (house mouse). One product is registered as a tracking powder for control of rats and mice indoors and at burrows located along the periphery of buildings. Because diphacinone salt is highly soluble, it is also used to prepare water baits for indoor control of rats and mice. Use sites for rat and mouse food baits are predominantly in and around buildings and similar man-made structures. Some labels include sewers or other wet or damp sites such as dumps, irrigation ditches, along fences, gullies, and other such areas. Diphacinone salt has special local needs registration in California for control of deer mice, jackrabbits, chipmunks, muskrats, woodrats, voles, and commensal rats and mice (USEPA 1998e).

4.5.2.1 Environmental Fate

Diphacinone has low water solubility and volatilizes slowly from water and soil. Diphacinone is stable to hydrolysis at pH 7-9 and stable to photolysis. One clearly established route of transformation for diphacinone is aerobic soil metabolism (Table 4-17). Because diphacinone binds tightly to soil, most of the chemical would remain in the top soil layers and its potential to reach ground water is low (USEPA 1998e, Federoff and Lin 2011).

Table 4-17 Degradation of Diphacinone

Degradation Method	Half-life	Reference
Hydrolysis, pH 5	44 Days	USEPA 1998e
Hydrolysis, pH 7-9	Stable	USEPA 1998e
Photolysis (water)	Stable	Federoff & Lin 2011
Photolysis (soil)	Stable	Federoff & Lin 2011
Aerobic metabolism (water)	180 Days	Federoff & Lin 2011
Aerobic metabolism (soil)	28 to 32 Days	USEPA 1998e, Federoff & Lin 2011

4.5.2.2 Human Toxicity

The USEPA has rated diphacinone as Category I for oral, dermal, and inhalation toxicity to mammals. Oral LD50s for rats were 2.3 mg/kg and 7.0 mg/kg in two separate studies (USEPA 1998e). The dermal LD50 for rabbits is 3.6 mg/kg. The inhalation LC50 for rats is <0.6 µg/L (USEPA 1998e). Diphacinone is listed as Category III for eye irritation and Category IV for skin irritation (USEPA 1998e). Given the exclusively nonfood uses of diphacinone, chronic toxicity and carcinogenicity, USEPA has not conducted chronic toxicity and carcinogenicity studies (USEPA 1998e). The use of rodenticides can sometimes pose risks to domestic animals via primary or secondary exposure. The oral LD50 is 3 to 7.5 mg/kg for dogs and 14.7 mg/kg for cats. The oral LD50 for swine is 150 mg/kg (EXTOXNET 1993b).

4.5.2.3 Ecological Toxicity

Diphacinone is slightly toxic to birds, and the use of food bait (aerial or ground broadcast or hand applied pellets) may present an exposure risk to seed-eating birds (USEPA 1998e). The oral LD50 is 3,158 mg/kg for mallard duck and 1,630 mg/kg for bobwhite quail (EXTOXNET 1993b). There is potential secondary risk to avian predators and scavengers, which may feed on poisoned rodents. The lowest observed lethal single dose to screech owls was 130 mg/kg bw (Rattner et al. 2012). The lowest observed lethal 7-day dose to screech owls was 0.82 mg/kg owl/day (Rattner et al. 2012). Primary risks to larger mammals are reduced by proper use of bait stations. The USEPA expects minimal risk to aquatic organisms from the current uses of

diphacinone (USEPA 1998e). However, diphacione is slightly to moderately toxic to fish and invertebrates. The 96-hr LC50 is 7.5 mg/L for bluegill and 2.8 mg/L for trout. The 48-hr LC50 for *Daphnia magna* is 1.8 mg/L (USEPA 1998e). It is not known to bioaccumulate in fish readily (USEPA 1998e).

4.5.2.4 Summary of Toxicity and Potential Effects

Diphacinone technical material has low water solubility and is generally applied as food bait blocks; however, diphacinone salt is highly soluble and is used to prepare water baits for indoor applications. Diphacinone salt has special local needs registration in California for control of deer mice, jackrabbits, chipmunks, muskrats, woodrats, voles, and commensal rats and mice (USEPA 1998e). It is highly toxic to mammals, including humans, domestic pets, and non-target mammalian wildlife. However, since it is generally applied as solid bait blocks or in-home water treatments, significant release and environmental impact is not anticipated.

Diphacinone is used by three Districts in tree holes, burrows, creeks, and parks. Districts use two different products. Diphacinone is applied over 80 times a year and application occurs in all four quarters, including during the reporting year. Active ingredient concentrations in these products are 0.2 and 0.005 percent, respectively. Based on the limited use patterns by the Districts and low potential exposure to non-target species, it is not likely that these products would result in adverse effects. For likely future uses, USEPA has released a list of new, more protective rodenticide products, including tamper-resistant and weather-resistant bait stations (http://www.epa.gov/pesticides/mice-and-rats/rodent-bait-station.html).

In addition to the toxicity values referenced in Sections 4.5.2.2 and 4.5.2.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.5.3 Brodifacoum

Brodifacoum is a second generation anticoagulant pesticide for rodent control against commensal rats and mice (Housenger and Melendez 2012). It is formulated as meal bait, paraffinized pellets, rat and mouse bait ready-to-use place packs, and paraffin blocks. Brodifacoum is currently registered for the control of rats and mice in and around farm structures, households and domestic dwellings, uncultivated agricultural and nonagricultural areas, inside transport vehicles, commercial transportation facilities, industrial areas, sewage systems, aircraft, ships, boats, railway cars, and food processing, handling, and storage areas and facilities. Only general-use brodifacoum products are currently registered (USEPA 1998e).

4.5.3.1 Environmental Fate

Brodifacoum has low solubility and is nonvolatile. It is stable to hydrolysis at pH 5, 7, and 9, relatively persistent in soil (half-life of 157 days), and immobile in soil columns. Photolysis by sunlight in aqueous media is potentially important, if exposure to aquatic environments occur. Brodifacoum is persistent in soil, but little, if any, contamination of surface and ground waters is expected because of its use pattern and immobility in soil (USEPA 1998e, Housenger and Melendez 2012).

4.5.3.2 Human Toxicity

Brodifacoum is listed as Category I for oral, dermal, and inhalation exposure by the USEPA. The oral LD50 for rats is 0.418 to 0.561 mg/kg. The dermal LD50 for rabbits is 3.16 to 5.21 mg/kg. The inhalation LC50 for rats is 3.05 to 4.86 µg/L. Brodifacoum is listed as Category III for eye irritation and is unlikely to cause skin irritation (USEPA 1998e) (Table 6-1).

4.5.3.3 Ecological Toxicity

Like other common rodenticides, brodifacoum is often found in tissues of wildlife. The LD50 for carnivores such as coyotes, foxes, and mountain lions is 0.27 to 25.0 mg/kg (Stone et al. 1999, Hosea 2000).

Eastern gray squirrels, white-tailed deer, raccoons, and red foxes have been recovered and determined to have died from exposure to anticoagulant rodenticides (first or second generation) (Stone et al. 1999). Domestic animals may accidentally ingest bait. The oral LD50 is 100 g of bait for cats and 355 to 1,000 g of bait for dogs (EXTOXNET 1985a).

The LD50 for wild birds, including some birds of prey ranges from 2 to 100 mg/kg (Stone et al. 1999, Hosea 2000).). The LD50 for mallard ducks is 0.26 mg/kg (USEPA 1998e). Scavenging birds may also be exposed to brodifacoum. Howald (1997) reported common ravens removed and consumed bait blocks from bait stations on Langara Island during a rat eradication program. Bald eagles captured and tested have also shown blood plasma residues of brodifacoum (Howald et al. 1999). Similar results have been demonstrated for northwestern crows (Howald 1997, Howald et al. 1999) and eastern screech owls (Merson et al. 1984) with some fatalities recorded. The level of concern (LOC) for predatory birds is >100 ng/g ww (hepatic concentration) with >200 ng/g considered potentially lethal (Christensen et al. 2012). Brodifacoum (in combination with bromadiolone and difethialone) was indicated in the mortality of three red-tailed hawks in Manhattan in 2012 (New York State Department of Environmental Conservation 2012). In a recent study of raptors and owls in Denmark, 92 percent of all birds contained detectable hepatic concentrations of anticoagulant rodenticides, with second-generation anticoagulants (brodifacoum, bromadiolone, and difenacoum the most prevalent) (Christensen et al. 2012).

The California Department of Fish and Game Pesticide Investigations Unit identified wildlife losses possibly due to pesticide exposure (Hosea 2000). Clinical signs consistent with anticoagulant toxicosis were observed during necropsies of 43 percent of the animals with anticoagulant residues. Of the 74-animals examined in this study, 69 percent had been exposed to anticoagulant rodenticides, indicating that urban use of anticoagulant rodenticides may be important in California. The primary compound identified in this study was brodifacoum (61 percent of mammals and 55 percent of birds). This compound was only registered for use in, or adjacent to, structures. Due to the feeding behaviors of some of the exposed non-target wildlife (i.e., birds of prey do not eat pelletized or grain foods, bobcats and mountain lions are carnivores) the authors concluded that it was unlikely for these species to consume rodenticide baits directly. Raccoons, canids, kangaroo rats, and wild turkeys were thought to have been exposed via the primary route. Acute LD50 data indicated that brodifacoum has the highest toxicity of the four identified rodenticides.

Brodifacoum is also very highly toxic to aquatic organisms, but due to its extremely low solubility, the USEPA does not believe the chemical poses a hazard to non-target aquatic organisms. The 96-hr LC50 is 0.025 mg/L for bluegill and 0.015 mg/L for rainbow trout (USEPA 1998e). Additionally, the USEPA has determined that brodifacoum does not pose a risk to honey bees (USEPA 1998e).

4.5.3.4 Summary of Toxicity and Potential Effects

Brodifacoum has low water solubility and is generally applied as food bait blocks or pellets. This second-generation rodenticide is highly toxic to mammals, including humans, domestic pets, and non-target mammalian wildlife. Brodifacoum is often found in the tissues of wildlife, including avian and mammalian predators. Compared to other rodenticides reviewed herein, brodifacoum has the greatest acute toxicity and is one of the most commonly identified poisons in tissues of non-target wildlife. Brodifacoum was not used by the Districts during the reporting year. Due to its limited use by the Districts, brodifacoum does not appear to be an active ingredient of concern, and using BMP application practices, these products should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Sections 4.5.3.2 and 4.5.3.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.5.4 Bromadiolone

Bromadiolone is an anticoagulant rodenticide that is used to control Norway rats (*Rattus norvegicus*), roof rats (*Rattus rattus*), and house mice (*Mus musculus*) in and around buildings and in transport vehicles (ships, trains, and aircraft), alleys, and sewers. Formulation types include meal bait, pellets, ready-to-use place packs, and paraffinized blocks (USEPA 1998e, Sternberg et al. 2011).

4.5.4.1 Environmental Fate

Bromadiolone is moderately persistent in soil and is immobile in soil with high organic and clay content. Bromadiolone is stable to hydrolysis at pH 5, 7, and 9. The major route of dissipation appears to be aerobic soil metabolism (half-life of 14-days).Two of the major degradates identified in the aerobic soil metabolism study are persistent (USEPA 1998e, Sternberg et al. 2011).

4.5.4.2 Human Toxicity

Bromadiolone is highly toxic to mammals by acute oral, dermal, and inhalation exposure. The oral LD50 is between 0.56 and 0.84 mg/kg for rats, although MacBean (2012) indicates the oral LD50 upper limit for rats is 1.31 mg/kg. The dermal LD50 is 1.71 mg/kg for rabbits. The inhalation LC50 is 0.43 µg/kg for rats. Bromadiolone is listed as Category III for eye irritation and IV for skin dermal irritation (USEPA 1998e).

4.5.4.3 Ecological Toxicity

Because bromadiolone is a rodenticide, risk is presumed for any small mammals that ingest bait containing the chemical (USEPA 1998e). Like other common rodenticides, bromadiolone is often found in tissues of wildlife. The LD50 for carnivores such as coyotes, foxes, and mountain lions is 1.125 to 25.0 mg/kg (Stone et al. 1999, Hosea 2000). Domestic animals may accidentally ingest bait. Acute toxicity for dogs (hemorrhages fatal if not treated) occurs at 10 mg/kg. For a 10 kg dog that would correspond to 100 mg of pure bromadiolone (2 kg bait at a typical application of 0.005 percent) (EXTOXNET 1985b). The maximum tolerated oral dosage for cats is 25 mg/kg (EXTOXNET 1985b).

The LD50 for wild birds, including birds of prey is 16.93 mg/kg (Stone et al. 1999, Hosea 2000). The LD50 is 138 mg/kg for bobwhite quail (USEPA 1998e). Bromadiolone (in combination with brodifacoum and difethialone) was indicated in the mortality of three red-tailed hawks in Manhattan in 2012 (New York State Department of Environmental Conservation 2012). In a recent study of raptors and owls in Denmark, 92 percent of all birds contained detectable hepatic concentrations of anticoagulant rodenticides, with second-generation anticoagulants (brodifacoum, bromadiolone, and difenacoum the most prevalent) (Christensen et al. 2012).

Bromadiolone bioconcentration factors (BCF) of 160X and 1,658X were determined for edible and nonedible tissues in bluegill sunfish, respectively (USEPA 1998e). The 96-hr LC50 is 0.24-mg/L for rainbow trout and 3.0 mg/L for bluegill (USEPA 1998e). The 24-hr LC50 for *Daphnia magna* is 8.8 mg/L (EXTOXNET 1985b). Due to the methods of bromadiolone application, little if any of the chemical is expected in water bodies. Additionally, bromadiolone is extremely insoluble and therefore is not expected to pose a major risk to aquatic organisms (USEPA 1998e).

4.5.4.4 Summary of Toxicity and Potential Effects

Bromadiolone is moderately persistent in soils and is generally applied as food bait blocks or pellets. This second-generation rodenticide is highly toxic to mammals, including humans, domestic pets, and non-target mammalian wildlife. Bromadiolone is often found in the tissues of wildlife, including avian and mammalian predators. Mortalities of raptors have been associated with secondary bromadiolone poisoning.

Bromadiolone is being used in and around manmade and natural standing and moving water, including during the reporting year. There are currently four Districts using a total of five products that contain bromadiolone (0.005 percent) for rodent control. These products were applied during all four quarters of

the reporting year. One product alone accounts for approximately 5 lbs AI applied per year (over 1,000 lbs of product). When deployed in sewers, bromadiolone blocks are sometimes attached to a string or wire and hung below manhole covers. This method of bait deployment reduces the probability of exposure (by multiple routes) to humans and non-target wildlife, especially dietary exposure (ingestion route) to ground-foraging birds and mammals. In addition, this rodenticide causes rapid mortality of targeted rats, therefore poisoned individuals tend to expire in the sewers and not represent prey for secondary consumers in the terrestrial environment. Further, bromadiolone is usually wax-encased (e.g., Contrac Blox) in block form, which has exceptionally low water solubility and low leaching potential.

Outside of sewers, bromadiolone is typically contained in tamper-proof bait stations, which are most frequently deployed at residential locations, and not near aquatic systems, open lands, or woodlands. Residential treatments involve bait station deployment generally within 50 feet of homes. Bait stations are anchored to treatment locations (e.g., wires, stakes, etc.) to ensure that they cannot be dragged away by wildlife. In addition, bait stations have small openings that prevent the entrance and exposure to non-rodent mammals (e.g., squirrels, skunks, etc.). Residents are properly educated regarding the location of deployed tamper-proof bait stations and potential risks to children and pets.

Bromadiolone is a single-dose rodenticide that when used properly (such as in the absence of food competition), causes rapid knock-down of rat populations and very limited potential for impacting aquatic systems and resulting in exposure to humans and non-target wildlife. If use is expanded by the Districts in the future or additional issues arise regarding the use of this rodenticide, new, more protective rodenticide bait station alternatives reported by the USEPA could be considered (http://www.epa.gov/pesticides/mice-and-rats/rodent-bait-station.html). Based on toxicity, environmental fate, and usage patterns, bromadiolone, using BMPs is not likely to result in unwanted adverse impacts.

In addition to the toxicity values referenced in Sections 4.5.4.2 and 4.5.4.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.5.5 Bromethalin

Bromethalin is often used to exterminate rodents resistant to first generation anticoagulant rodenticides. Bromethalin is easily confused with second generation anticoagulant rodenticides (brodifacoum, bromadiolone) due to naming similarities. After ingestion, bromethalin is rapidly absorbed and undergoes N-demethylation in the liver, forming desmethyl bromethalin, which is thought to be the major toxic metabolite. The plasma half-life of bromethalin is about six days in rats. Excretion occurs mainly in bile and enterohepatic resuspension is suspected. The mode of action is the uncoupling of oxidative phosphorylation, which leads to decreased cellular ATP production and failure of Na+, K+-ATPase pumps. The cells lose osmotic control and swell. Cerebral and spinal cord edema elevates cerebrospinal fluid pressures and leads to neurologic dysfunction. Bromethalin toxicosis in dogs manifests as either paralytic or convulsant syndrome. Cats develop paralytic syndrome at all doses (Dunayer 2003).

Some bromethalin products meet the USEPA's new, more protective risk reduction standards. When applied properly, these products present a lower risk of accidental exposure to children, pets, and wildlife. They are applied in tamper-resistant and weather-resistant bait stations (USEPA 2013).

4.5.5.1 Environmental Fate

Bromethalin is stable to hydrolysis and is persistent to aerobic soils. In addition, a major degradate, desnitrobromethalin, also appears to be persistent and its mobility has not been characterized. However, because bromethalin is formulated as pelleted food bait, total usage of the active ingredient is low and ground water leaching and surface runoff is expected to be minimal (USEPA 2011).

Table 4-18 Degradation of Bromethalin

Degradation Method	Half-life	Reference
Hydrolysis	Stable	USEPA 2011
Aerobic metabolism (soil)	178 Days	USEPA 2011

4.5.5.2 Human Toxicity

Bromethalin is classified as very highly toxic to mammals on an acute oral basis. The acute oral (14-day) LD50 of bromethalin is 2.11 mg/kg for rats (USEPA 2011). The oral LD50 is 2.38 to 5.6 mg/kg for dogs and 0.54-mg/kg for cats (USEPA 2011). The minimum lethal oral dose for cats is 0.45 mg/kg (USEPA 2011). The acute percutaneous LD50 for male rabbits is 1000 mg/kg and the one hour inhalation LC50 for rats is 0.24 mg/L (MacBean 2012).

4.5.5.3 Ecological Toxicity

Bromethalin is classified by the USEPA as highly toxic to birds and mammals on an acute oral basis and as highly toxic to birds on a subacute dietary basis. The acute oral (14-day) LD50 for bobwhite quail is 4.56 mg/kg (USEPA 2011). Data are not available to characterize the toxicity of bromethalin to non-target invertebrates such as honey bees. Very little research has been conducted to directly measure the secondary poisoning hazard of bromethalin. Aquatic exposure is expected to be negligible based on the use patterns of bromethalin and there are currently limited data available on the toxicity of this rodenticide to fish or aquatic invertebrates. The LC50 for bluegill and trout has been reported as 0.598 and 0.038 mg/L respectively. The EC50 for Daphnia has been reported as 2 µg/L (www. pesticideinfo.org). The USEPA has listed bromethalin as “may affect” and “likely to adversely affect” the federally threatened Alameda whipsnake and the endangered salt marsh harvest mouse in California (USEPA 2011).

4.5.5.4 Summary of Toxicity and Potential Effects

Due to its acute toxicity to rodents and mammals, and the potential for exposure to non-target pets and wildlife, use of bromethalin requires a thorough understanding of possible routes of exposure. Placement and amounts of bromethalin used are critical factors in reducing potential unwanted secondary exposures and effects. Many uses of this product include subterranean placement to poison moles and voles (usually in worm-like commercial products). Some recent bromethalin products meet the USEPA’s new, more protective risk reduction standards; and using proper application techniques they can result in a lower risk of accidental exposure to children, pets, and wildlife. They can also be applied in tamper-resistant and weather-resistant bait stations. Use of these products should always include appropriate BMPs and prior evaluation of the potential predators and non-targets that might consume this product.

In addition to the toxicity values referenced in Sections 4.5.5.2 and 4.5.5.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.5.6 Difethialone

Difethialone is an anti-coagulant rodenticide that is registered for use only in baits for control of three commensal rodents: the Norway rat (*Rattus norvegicus*), the roof rat (*Rattus rattus*), and the house mouse (*Mus musculus*). Formulation types registered include pellets, pellet packs, blocks, mini blocks, paraffin blocks, meal, packs or pouches, paste and bait stations. Currently, labeled uses of difethialone include in and around homes, and agricultural, industrial and commercial buildings, transport vehicles and associated ports, alleys and sewers (Housenger and Melendez 2011).

Difethialone was introduced as a second-generation rodenticide in 1986 for the control of commensal rats and mice including those resistant to first-generation anticoagulants. Difethialone inhibits the vitamin K-dependent step in the synthesis of a number of blood coagulation factors, disrupts normal blood-clotting mechanisms, and induces capillary damage (Housenger and Melendez 2011).

4.5.6.1 Environmental Fate

Difethialone adsorbs to suspended solids and sediment and is immobile in soil. Difethialone can slowly volatilize from water surfaces. The compound is relatively stable to hydrolysis and aerobic metabolism, but degrades rapidly by photolysis (Table 4-19).

Table 4-19 Degradation of Difethialone

Degradation Method	Half-life	Reference
Hydrolysis, pH 5-9	154 to 211 Days	Housenger & Melendez 2011
Photolysis, pH 5-9 (water)	57 to 62 minutes	Housenger & Melendez 2011
Aerobic metabolism (soil)	204 Days	Housenger & Melendez 2011

4.5.6.2 Human Toxicity

Difethialone is very toxic to mammals by all acute exposure routes. The LD50 for male rats is 0.55 mg/kg bw. The LD50 for mice is 1.29 mg/kg bw. The dermal LD50 is 6.5 mg/kg bw for rats. The inhalation LC50 is ≥ 5.0 µg/L in 4 hrs but ≤19.3 µg/L in 4-hrs for rats (Annex I - Norway 2007). Difethialone is not known to cause skin or eye irritation. No genotoxic or carcinogenic effects have been noted (Annex I - Norway 2007).

4.5.6.3 Ecological Toxicity

Difethialone is likely very toxic to most mammals. Domestic animals are somewhat less susceptible than rats and mice. The LD50 is 11.8 mg/kg bw for dogs and ≥ 16 mg/kg bw for cats. A dog would have to ingest 400 g of bait for mortality to occur (Lechevin and Poche 1988). The LD50 for domestic pigs is between 2.0 and 3.0 mg/kg bw (Annex I - Norway 2007). Difethialone is also acutely toxic by dermal and inhalation exposure. The dietary LC50 for ferrets is 97.7 mg active ingredient/kg (Savarie 2005). USEPA studies concluded that, based on the best available information, difethialone is “likely to adversely affect” Alameda whipsnake, salt marsh harvest mouse, and San Joaquin kit fox (Housenger and Melendez 2011) Risk evaluation indicated that the registered uses of difethialone exceed acute LOCs for the small mammalian weight class of salt marsh harvest mouse. Kit fox are likely to be affected via secondary exposure as well as indirectly from reduced prey availability (small mammals). The whipsnake may be affected as the acute Risk Quotients exceed the LOC for both primary and secondary exposure and habitat modification would also occur (fewer small mammal burrows) (Housenger and Melendez 2011). The recommended action was that a formal consultation with USFWS under Section 7 of the ESA be initiated.

Difethialone is very highly toxic to birds on an acute oral and subacute dietary exposure basis (Housenger and Melendez 2011). Difethialone is acutely toxic to birds. The LD50 for bobwhite quail is 0.264-mg/kg bw (Annex I - Norway 2007). The dietary LC50 for magpies is 4.48 mg active ingredient/kg diet (Savarie 2005). Secondary exposure of birds of prey has been demonstrated. A study of barn owls gave a low LD100 between 0.27 and 0.39 mg/kg bw (Annex I - Norway 2007). There are no data to characterize chronic toxicity to birds and mammals (Housenger and Melendez 2011). Difethialone is highly toxic to aquatic organisms. The 96-hr LC50 for rainbow trout is 51 µg/L. The 48-hr EC50 for *Daphnia magna* is 4.4-µg/L. There are no data to characterize toxicity of difethialone to the honey bee.

4.5.6.4 Summary of Toxicity and Potential Effects

Difethialone is persistent in soils and is generally applied as food bait blocks or pellets. This second-generation rodenticide is highly toxic to mammals, including humans, domestic pets, and non-target mammalian wildlife. Difethialone is often found in the tissues of wildlife, including avian and mammalian predators. Difethialone has been categorized as "likely to adversely affect" several species of sensitive California wildlife and registered uses of difethialone exceed the LOC for both primary and secondary exposure. Indirect effects to habitat have been suggested for areas where difethialone is used for pest control (Housenger and Melendez 2011).

One product containing difethialone (0.0025 percent) is used by two Districts for rat control and is applied around creeks, parks, and landscaping. Application typically occurs in the fall, winter, and spring, including 19 applications during the reporting year.

Difethialone is used in areas frequented by humans and domestic animals (parks, landscaped areas) during much of the year. The availability of new, more protective rodenticide bait stations reported by the USEPA, should be considered when available. (http://www.epa.gov/pesticides/mice-and-rats/rodent-bait-station.html).

In addition to the toxicity values referenced in Sections 4.5.6.2 and 4.5.6.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.5.7 Cholecalciferol

Cholecalciferol is used to control Norway rats (*Rattus norvegicus*), roof rats (*Rattus rattus*), and house mice (*Mus musculus*) in and around homes, industrial buildings and similar man-made structures, in and around agricultural buildings, including swine, poultry, cattle and dairy facilities, warehouses and food storage areas; in transport vehicles (ships, trains and aircraft) and in and around related port and terminal buildings; and in alleys. Formulation types include pellets and blocks (Clock-Rust and Sutton 2011). Cholecalciferol is a sterol (vitamin D3) and its ingestion results in hypercalcemia from mobilization of calcium from bone matrix into blood plasma leading to metastatic calcification of soft tissues (Clock-Rust and Sutton 2011).

4.5.7.1 Environmental Fate

The environmental fate of cholecalciferol is not well described. Based on physical/chemical properties of cholecalciferol, it is expected to be nonvolatile, essentially insoluble in water and immobile in soil (Clock-Rust and Sutton 2011). Information on biotic and abiotic degradation was not available.

4.5.7.2 General Toxicity

The parent compound and metabolites are fat soluble and stored in adipose tissue. Enterohepatic recirculation of cholecalciferol and metabolites occurs. After a massive intake of cholecalciferol, excess calcifediol is produced in the liver. Because of their high lipid solubility, cholecalciferol and its metabolites are eliminated from the body very slowly (primarily through bile and feces). Two mechanisms occur with consumption of large doses of cholecalciferol. First, more calcium is absorbed from the intestines. Second, cholecalciferol metabolites stimulate phosphorus transfer from bone to plasma. The increased plasma calcium concentrations result in vomiting, lethargy, and muscle weakness. Specific organ effects include acute renal tubular necrosis, gastrointestinal stasis, gastric acid secretion, decreased skeletal muscle responsiveness, and decreased neural tissue responsiveness. The increase in plasma calcium causes soft tissue mineralization resulting in loss of functionality of kidneys, cardiac muscle, etc. (Morrow 2001).

4.5.7.3 Human Toxicity

Cholecalciferol is acutely toxic to target rodents. The oral LD50 for cholecalciferol dissolved in corn oil is 42.5 mg/kg for mice and 43.6 mg/kg for rats (Marshall 1984). The dermal LD50 of the finished bait product (0.075 percent cholecalciferol) is 2,000 mg/kg for rabbits (Marshall 1984) (Table 6-1).

4.5.7.4 Ecological Toxicity

Cholecalciferol is considered of low hazard to avian and canine species. The oral LD50 for dogs is 88 mg/kg. The oral LD50 for mallard ducks and bobwhite quail is 2,000 mg/L (Marshall 1984). When used in bait form, cholecalciferol may directly impact sensitive species such as non-target rodents (Clock-Rust and Sutton 2011). Cholecalciferol is not expected to bioconcentrate since it is metabolized in mammals (Clock-Rust and Sutton 2011)

4.5.7.5 Summary of Toxicity and Potential Effects

Cholecalciferol is essentially insoluble in water and immobile in soils. It is generally applied as food bait blocks or pellets. The mode of action of cholecalciferol differs from the other rodenticides examined herein in that it is not an anticoagulant. Rather, cholecalciferol baits deliver a toxic dose of vitamin D to pests. Although it is highly toxic to target rodents, cholecalciferol is considered of low hazard to non-targets such as birds or domestic dogs.

Cholecalciferol is used in one product (0.075 percent) by one District. It is used along creeks, parks, and waterfronts in the fall, winter, and spring. Cholecalciferol was used on 26 occasions accounting for total application of 37 ounces of product (2.8 oz. active ingredient). Based on the reported usage, using BMP application practices, these products should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Sections 4.5.7.3 and 4.5.7.4, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.5.8 Sulfur (fumigant)

Elemental sulfur is a naturally occurring component of the earth's core and crust and is ubiquitous in the environment. Sulfur has been used as a pesticide in the United States since the 1920s, and is currently registered for use as an insecticide and fungicide on a wide range of field and greenhouse-grown food and feed crops, livestock (and livestock quarters), and indoor and outdoor residential sites. Sulfur is also one of the active ingredients in four fumigant (gas-producing) cartridge products (e.g., PROFUME etc.) which are used for rodent control on lawns, golf courses, and in gardens. Carbon, sodium and potassium nitrates, sawdust, and sulfur are used in the pyrotechnic fumigant gas producing cartridge products. After the cartridges are ignited, they produce toxic gases that cause asphyxiation of the pests. These toxic gases, not the active ingredients, are the stressors for these products. The gases displace the oxygen in the burrows, creating an un-breathable atmosphere, causing asphyxiation of the target organisms (MSDS 007736, PROFUME, Dow AgroSciences 2004)

4.5.8.1 Human Toxicity

Elemental sulfur is known to be of low toxicity and poses little, if any, risk to human health. The USEPA classifies sulfur as Category IV (least toxic) for acute oral toxicity (EXTOXNET 1995b). The oral LD50 for rats is >5,000 mg/kg. The dermal LD50 for rats is also >2,000 mg/kg. Acute inhalation exposure can cause respiratory irritation. The inhalation LC50 for 98 percent sulfur in rats is >2.56 mg/L. Sulfur is not a skin sensitizer. No known risks of oncogenic, teratogenic, or reproductive effects are associated with the use of sulfur (EXTOXNET 1995b).

4.5.8.2 Ecological Toxicity

Sulfur is nontoxic to birds (EXTOXNET 1995b). The 8-day dietary LC50 for bobwhite quails is >5,620 mg/L for 95 percent sulfur wettable powder. Sulfur is of practically nontoxic to aquatic organisms (EXTOXNET 1995b). The 96-hr LC50 for bluegill and rainbow trout is >180 mg/L using a 99.5 percent sulfur dust formulation. The 48-hr LC50 for *Daphnia magna* is >5,000 mg/L using 90 percent sulfur. Sulfur is considered nontoxic to bees (EXTOXNET 1995b).

4.5.8.3 Summary of Toxicity and Potential Effects

Sulfur fumigants are of low toxicity prior to activation of sulfur-containing cartridges. Elemental sulfur will become incorporated back into the natural sulfur cycle after deployment. Sulfur fumigant cartridges are placed in pest burrow and produce toxic gases, which will negatively impact any animal in the burrow. Therefore, sulfur fumigants should not be applied when there is evidence of non-target animal presence. Sulfur fumigants were not used by the Districts during the reporting year and risk to non-targets is readily avoided by inspecting application sites thoroughly, therefore; using BMP application practices, these products should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Sections 4.5.8.1 and 4.5.8.2, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.5.9 Sodium Nitrate (fumigant)

Sodium nitrate is used with other components as an active ingredient to control mammals such as woodchucks, ground squirrels, and coyotes in open fields, noncrop areas, rangelands, lawns and golf courses. End-use products containing sodium nitrate are used as fumigant gas cartridges designed to be placed in burrows. The sodium nitrate supports the combustion of charcoal in the formulation of each product. Pyrolysis of sodium nitrate products results in release of simple organic and inorganic compounds, such as nitrous oxide and carbon monoxide. These gases eventually diffuse through burrow openings or into the soil causing organisms to die of asphyxiation (USEPA 1991d).

4.5.9.1 Human Toxicity

Available acute toxicity studies indicate that sodium nitrate may cause eye irritation (Category II) and slight dermal irritation (Category IV) to mammals, but pose relatively low acute oral toxicity (Category III) hazard (USEPA 1991b). The only people exposed to sodium nitrates should be pesticide applicators and they should be exposed only minimally (USEPA 1991b). The USEPA believes that sodium nitrates, when used as indicated, do not present any unreasonable adverse effects to humans.

4.5.9.2 Ecological Toxicity

Sodium nitrates are naturally occurring substances and exposure of the environment is limited and localized when the products are used as fumigants in burrows (USEPA 1991b). When used as indicated by the product label, any organism inside of a treated burrow would likely be killed by the toxic fumes. The nonselective nature of this pesticide is particularly problematic when protected species are present. Nontarget species such as burrowing owls, black-footed ferrets, kangaroo rats, or desert tortoises often inhabit pest burrows and may be at risk (Keefover-Ring 2009). USEPA recommends that applicators observe signs around burrows indicating the presence of non-target species and use caution.

4.5.9.3 Summary of Toxicity and Potential Effects

Sodium nitrate fumigants are of low toxicity prior to activation of the cartridges. Sodium nitrates are naturally occurring substances. Sodium nitrate fumigant cartridges are placed in pest burrow and produce toxic gases, which will negatively impact any animal in the burrow. Therefore, sodium nitrate fumigants

should not be applied when there is evidence of non-target animal presence. Sodium nitrate fumigants were not used by the Districts during the reporting year and risk to non-targets is readily avoided by inspecting application sites thoroughly; therefore, using BMP application practices, these products should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Sections 4.5.9.1 and 4.5.9.2, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.6 Herbicides

4.6.1 Imazapyr

Imazapyr is part of the imidazolinone chemical class. Imazapyr is a systemic, nonselective, pre- and post-emergent herbicide used for the control of a broad range of terrestrial and aquatic weeds, and controls plant growth by preventing the synthesis of branched-chain amino acids. Imazapyr is applied either as an acid or as the isopropylamine salt. Imazapyr is used for pre- and post-emergence control of a broad range of weeds, including terrestrial annual and perennial grasses, broadleaf herbs, woody species, and riparian and emergent aquatic species. Agricultural uses of imazapyr include field corn and grass. Imazapyr is also registered for use on a variety of commercial and residential use sites, including forestry sites, rights-of-way, fence rows, hedge rows, drainage systems, outdoor industrial areas, outdoor buildings and structures, domestic dwellings, paved areas, driveways, patios, parking areas, walkways, various water bodies (including ponds, lakes, streams, swamps, wetlands, stagnant water, and urban areas) (USEPA 2006b).

4.6.1.1 Environmental Fate

Imazapyr is an anionic, organic acid that is nonvolatile and is both persistent and mobile in soil. Commercial formulations contain either imazapyr acid or the imazapyr isopropylamine salt, both of which are dissolved in a water solution. Imazapyr is mainly in ionic form at typical environmental pH levels, and the behavior of the acid and salt forms are similar. Upon direct application, or indirect release into surface water, photolysis is the only identified mechanism for imazapyr degradation in the environment (Table 4-20), with a half-life of approximately 3 to 5 days in surface water. Laboratory studies show imazapyr is essentially stable to hydrolysis, aerobic and anaerobic soil degradation, as well as aerobic and anaerobic aquatic metabolism. Field dissipation study observations are consistent with imazapyr's intrinsic ability to persist in soils and move via runoff to surface water and to leach to groundwater (USEPA 2006b).

Table 4-20 Degradation of Imazapyr

Degradation Method	Half-life	Reference
Hydrolysis	Stable	USEPA 2006b
Photolysis (water)	3 to 5 Days	USEPA 2006b
Aerobic metabolism (water and soil)	Stable	USEPA 2006b
Anaerobic metabolism (water and soil)	Stable	USEPA 2006b

4.6.1.2 Human Toxicity

Imazapyr is slightly toxic to mammals via oral, dermal, and inhalation exposure. The oral LD50 for rats is >5,000 mg/kg. The dermal LD50 for rabbits is >2,000 mg/kg. The inhalation LC50 for rats is >1.3 mg/L (USDOE-Bonneville Power Administration 2000). MacBean (2012) reports the inhalation LC50 for rats is greater than 5.1 mg/L (Table 6-1). There is no evidence that imazapyr is carcinogenic or mutagenic

(USDOE-Bonneville Power Administration 2000). The USEPA has determined that the risk to humans of dietary and incidental exposure is below the level of concern (USEPA 2006b). Imazapyr is classified as a Category I primary eye irritant (USEPA 2006b).

4.6.1.3 Ecological Toxicity

Imazapyr is practically nontoxic to birds, fish, *Daphnia*, and honey bees. The oral LD50 for mallard ducks is >2,150 mg/kg. The 96-hr LC50 for rainbow trout is >100 mg/L. The 48-hr LC50 for *Daphnia magna* is >1,000 mg/kg. The LD50 for honey bees is >100 µg/bee (USDOE-Bonneville Power Administration 2000). Although there are no risks of concern to terrestrial birds, mammals, and bees or aquatic invertebrates and fish, imazapyr does pose an ecological risk to non-target terrestrial and aquatic vascular plants (USEPA 2006b). Imazapyr is not expected to bioaccumulate in aquatic organisms because it exists as an anion at typical environmental pHs (USEPA 2006b).

4.6.1.4 Summary of Toxicity and Potential Effects

Imazapyr is persistent in soil and also tends to leach to groundwater. It is of low acute toxicity to mammals and practically nontoxic to birds, fish, and invertebrates. Non-target plants may be at risk from imazapyr application. Based upon the toxicity and environmental fate of imazapyr, and using BMP application practices, these products should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Sections 4.6.1.2 and 4.6.1.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.6.2 Glyphosate

Glyphosate is a nonselective, post-emergent, and systemic herbicide registered for use in agricultural and nonagricultural areas. It is applied to agricultural drainage systems, irrigation systems, sewage systems, forest trees, greenhouses, outside of household/domestic dwellings, and to a variety of feed and food crops. When applied at lower rates, glyphosate is a plant growth regulator (USEPA 1993). It works by inhibiting the synthesis of the enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSP), which is needed for production of amino acids. These amino acids aid in synthesis of proteins that link primary and secondary metabolism. Glyphosate is not effective on submerged or mostly submerged foliage and therefore is only applied to control emergent foliage (Schuette 1998, Siemering 2005).

4.6.2.1 Environmental Fate

Glyphosate is highly water-soluble. Glyphosate is broken down by microbial degradation to its metabolite aminomethylphosphonic acid (AMPA) and carbon dioxide. The rate of degradation in water is generally slower than the rate in soil because there are fewer microorganisms in water than in most soils. For all aquatic systems, sediment appears to be the major sink for glyphosate residue. Even though glyphosate is highly water soluble it appears that parent glyphosate and AMPA have a low potential to move to groundwater due to their strong soil adsorptive characteristics (USEPA 1993, Schuette 1998, Siemering 2005).

In the soil environment, glyphosate is resistant to chemical degradation, is stable to sunlight, is relatively nonleachable, and has a low tendency to runoff (except as adsorbed to colloidal matter and sediment). It is relatively immobile in most soil environments as a result of its strong adsorption to soil particles and does not move vertically below the 6 inch soil layer. Glyphosate's primary route of decomposition in the environment is through microbial degradation in soil (Table 4-21). The herbicide is inactivated and biodegraded by soil microbes at rates of degradation related to microbial activity in the soil and factors that affect this activity. The biological degradation process is carried out under both aerobic and anaerobic conditions by soil microflora (USEPA 1993, Schuette 1998).

Table 4-21 Degradation of Glyphosate

Degradation Method	Half-life	Reference
Hydrolysis	>35 Days, Stable	USEPA 1993 Schuette 1998
Photolysis (water)	Stable (pH 5,7 and 9)	USEPA 1993
Photolysis (soil)	Stable	USEPA 1993
Aerobic metabolism (water)	7 Days	USEPA 1993
Aerobic metabolism (soil)	1.85 to 25 Days	USEPA 1993
Anaerobic metabolism (soil)	8.1 to 22.1 Days	USEPA 1993, Schuette 1998
Field dissipation (soil)	44 to 60 Days	Schuette 1998
Streams, ponds, natural waters	1.5 to 63 Days	Schuette 1998

4.6.2.2 General Toxicity

Glyphosate is an herbicide designed to specifically affect plants via the shikimic acid pathway. Glyphosate inhibits the enzyme 5-enolpyruvylshikimate 3-phosphate (EPSP) synthase, which is absent in mammals (Miller et al. 2010). The resulting deficiency in EPSP production leads to reductions in aromatic amino acids necessary for plant protein synthesis and growth. Glyphosate is absorbed directly across the leaves and stems and is translocated throughout the plant, concentrating in the meristem (Miller et al. 2010). The effects of the herbicide are generally visible between 4 and 20 days post-application and include stunted growth, loss of pigmentation, malformation or wrinkling of leaves, and ultimately tissue death (Miller et al. 2010). There are several formulations of glyphosate, including an acid, monoammonium salt, diammonium salt, isopropylamine salt, potassium salt, sodium salt, and trimethylsulfonium or trimesium salt. The commonly used Roundup™ products are isopropylamine salt formulations. The salts do not contribute to the weed control activity; therefore, the acid equivalent (ae) of glyphosate acid is the most accurate method of expressing and comparing concentrations.

4.6.2.3 Human Toxicity

The shikimic acid pathway is specific to plants and some microorganisms; therefore, glyphosate is thought to have very low toxicity to mammals (USEPA 1993). The USEPA classifies glyphosate as Category III for oral and dermal toxicity (USEPA 1993). The oral LD50 for technical grade glyphosate for rats is 4,320 mg/kg (USEPA 1993). The dermal LD50 for technical grade glyphosate in rabbits is ≥2000 mg/kg (USEPA 1993). Technical grade glyphosate is nonvolatile and the LC50 for rats is ≥4.43 mg/L based on a 4-hr, nose-only inhalation study (USEPA 1993, Miller et al. 2010).

The isopropylamine and ammonium salts exhibit low toxicity to mammals via the oral and dermal routes. The oral LD50 for the isopropylamine salt in rats is ≥ 5,000 mg/kg. The oral LD50 for the ammonium salt form in rats is 4,613 mg/kg. The dermal LD50 for rabbits is ≥ 5,000 mg/kg for both salts (Miller et al. 2010). The salt formulations of glyphosate also exhibit low toxicity via the inhalation route. The 4-hr LC50 for rats exposed to the isopropylamine form is >1.3 mg/L air. The LC50 for rats exposed to the ammonium salt form was >1.9 mg/L in a whole-body exposure (Miller et al. 2010).

A one-year feeding study resulted in no chronic effects in beagle dogs at daily doses of 500 mg/kg (USEPA 1993). There is currently no published scientific evidence indicating that glyphosate is carcinogenic or mutagenic unless workers are exposed to extended, unrealistic industrial uses (USEPA 1993, Gertsberg, 2011). Experimental evidence has shown that neither glyphosate nor its major breakdown product (aminomethylphosphonic acid [AMPA]) bioaccumulates in any animal tissue (Williams

et al. 2000). Glyphosate is poorly biotransformed in rats and is excreted mostly unchanged in the feces and urine (Williams et al. 2000).

Despite the apparent lack of toxicity to mammals, concerns have been raised about the long-term safety of glyphosate. In one study, glyphosate has been shown to alter the respiratory and hepatic systems of rats and to cause damage to reproductive functions and fetal development (Clair et al. 2012). Additionally, a recent study found significant contamination in all urine samples taken from an urban human population in Germany. The levels of glyphosate in the subjects' urine were 5 to 20 times the maximum allowable limit for drinking water (Brandli and Reinacher 2012). In another study, rats and mice were fed a diet containing glyphosate for 13 weeks. The two highest dose groups of male rats (25,000 and 50,000 mg/kg of 99 percent pure glyphosate) had significant reductions in sperm concentrations (Chan and Mahler 1992). Female rats in the 50,000 mg/kg group had slightly longer estrus cycles than the control group (Chan and Mahler 1992). Although still in review, glyphosate is included in the final list of chemicals for screening under the USEPA Endocrine Disruptor Screening Program (USEPA 2009a).

4.6.2.4 Ecological Toxicity

Glyphosate is practically nontoxic to birds. The oral LD50 for bobwhite quail is >2,000 mg/kg. It is also practically nontoxic to freshwater fish. The 48-hr LC50 for bluegill sunfish is >24-mg/L (USEPA 1993). Maximum bioconcentration factors were 0.52 times for whole fish (USEPA 1993). MacBean reports the 96-hr LC50 values for the isopropyl ammonium formulation is greater than 1,000 mg/L for both bluegill and trout. Technical grade glyphosate is slightly toxic to practically nontoxic to freshwater invertebrates with 48-hr LC50s ranging from 55 to 780 mg/L. LC50 values have also been obtained for several species of frogs and the American toad. The reported 24-hr LC50 for amphibians ranged from 6.6 to 18.1 mg/L (Howe et al. 2004). No significant acute toxicity to amphibians was observed with the technical material or the products (e.g., Roundup Original). Glyphosate is practically nontoxic to honey bees. The acute oral LD50 is >100 µg/bee (USEPA 1993) (Table 6-1).

4.6.2.5 Summary of Toxicity and Potential Effects

Products currently available containing glyphosate include Roundup, Rodeo, Pondmaster, ProMax, Proud 3®, Aquamaster, Alligare, and Buccaneer Plus. Each has a formulation with a slight variation of toxicity and environmental characteristics. This summary is focused on the active ingredient, N-(phosphonomethyl) glycine.

Using BMP approaches, applications of glyphosate can be used safely when an adequate buffer to water sources is maintained. Although there has been some recent concerns expressed about possible sub-lethal effects of glyphosate products, it is virtually nontoxic to mammals and practically nontoxic to birds, fish, and invertebrates. Glyphosate has been identified as a candidate by USEPA for evaluation as a potential endocrine disruptor (USEPA 2009a). Based on these issues, it is likely that USEPA will provide an updated review of its potential risks in 2015, but until then, glyphosate products are effective products used for weed control. Concerns about endocrine disruption by glyphosate are not verified and this chemical is only one of the dozens of chemicals USEPA is suggesting may have an EDC role. No significant indication of this mode of action has been reported at this time. Some reports of sub-lethal effects on disease resistance, biological diversity, enzyme activity, and increased use of genetically engineered foods are interesting but without clear mechanisms that can be related directly to glyphosate (Gertsberg 2011).

In addition to the toxicity values referenced in Sections 4.6.2.3 and 4.6.2.4, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.6.3 Triclopyr

Triclopyr is a pyridine-based herbicide used for the control of woody plants and annual and perennial broadleaf weeds. The two registered formulations are triclopyr triethylamine salt (TEA) and triclopyr butoxyethyl ester (TBEE). Triclopyr TEA rapidly dissociates in water to the triclopyr acid/anion and triethanolamine. Triclopyr BEE rapidly hydrolyses in the environment to the triclopyr acid/anion and butoxyethanol. It is the triclopyr acid (known simply as triclopyr) that causes phytotoxicity. Triclopyr is used at railroad or other rights-of-way, for commercial and residential use, and on rice, pasture, and woodlands. Triclopyr is absorbed by leaves and roots and is moved throughout the plant. The triclopyr TEA formulation is also used to control aquatic plant species. Triclopyr is a pyridine-based herbicide that acts as a synthetic auxin, giving a plant an auxin overdose 1,000 times natural levels (Ganapathy 1997). Triclopyr is absorbed by leaves and roots and is moved through the plant into the foliage rapidly. The effects occur at the cellular level first when ethylene and protein production in the plant increases first, followed by epinasty, abnormal leaf formation, and stem swelling, and death. Triclopyr has low phytotoxicity to grasses, but can cause injury to conifers at high application rates (Ganapathy 1997).

4.6.3.1 Environmental Fate

Triclopyr is nonvolatile and highly soluble. Triclopyr is “slightly mobile” with sorption to soil increasing with time. Triclopyr is moderately persistent, with persistence increasing as it reaches deeper soil levels and anaerobic conditions. The predominant degradation pathway for triclopyr in water is photodegradation and the predominant degradation pathway in soil is microbial degradation (Table 4-22) (Ganapathy 1997, USEPA 1998h).

Table 4-22 Degradation of Triclopyr

Degradation Method	Half-life	Reference
Hydrolysis, pH 5-9	270 Days, Stable	USEPA 1998c,h, Ganapathy 1997
Photolysis (water)	0.36 to 1.7 Days	USEPA 1998c,h
Aerobic metabolism (water)	142 Days	USEPA 1998c,h
Aerobic metabolism (soil)	8 to 18 Days	USEPA 1998c,h
Anaerobic metabolism (water)	>365 Days	USEPA 1998c,h
Field dissipation (water)	0.5 to 3.5 Days	USEPA 1998c,h, Ganapathy 1997
Field dissipation (soil)	10.4 to 33 Days	USEPA 1998c,h, Ganapathy 1997

4.6.3.2 Human Toxicity

Triclopyr is slightly toxic to mammals by oral and dermal routes and has been classified as Category III by the USEPA (USEPA 1998c). The TBEE formulation is slightly toxic by the oral and dermal route (Category III) and practically nontoxic by inhalation (Category IV) (USEPA 1998c). The oral LD50 for technical triclopyr in rats is 630 mg/kg for females and 729 for males (USEPA 1998c). Triclopyr is not carcinogenic. The dermal LD50 in rabbits has been reported to be greater than 2000 mg/kg. The inhalation LC50 in rats has been reported to be greater than 256 mg/L (MacBean 2012).

4.6.3.3 Ecological Toxicity

Triclopyr is rapidly absorbed by animals and then excreted by the kidney, primarily in the unmetabolized form. Aquatic organisms are more susceptible to triclopyr. Triclopyr acid is slightly toxic to birds and practically nontoxic to insects, freshwater fish, and aquatic invertebrates. The oral LD50 of triclopyr acid for mallard ducks is 1,698 mg/kg. The 96-hr LC50 for rainbow trout is 117 mg/L. The 96-hr LC50 for

Daphnia magna is 132 mg/L. The LD50 for honey bees is 60.4-µg/bee (Ganapathy 1997), although MacBean (2012) reports the contact LD50 is greater than 100 µg/bee. Triclopyr does not bioaccumulate rapidly (Ganapathy 1997, USEPA 1998c).

The TBEE formulation is slightly toxic to birds, moderately toxic to highly toxic to freshwater fish and slightly to moderately toxic to freshwater invertebrates. The 96-hr LC50 of TBEE to bluegill sunfish is 0.36 mg/L (Ganapathy 1997). The TEA formulation is practically nontoxic to birds and invertebrates and moderately to highly toxic to fish (USEPA 1998c).

4.6.3.4 Summary of Toxicity and Potential Effects

Triclopyr is highly soluble and slightly mobile in soil. Technical triclopyr, TEA, and TBEE have similar slight toxicity to mammals, birds, fish, and invertebrates. It also has low toxicity to non-target grasses, but can cause injury to conifers. Based upon the toxicity and environmental fate of triclopyr, and using BMP application practices, these products should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Sections 4.6.3.2 and 4.6.3.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.6.4 2,4-Dichlorophenoxy acetic acid (2,4-D)

The compound 2, 4-dichlorophenoxyacetic acid (2,4-D) is an herbicide in the phenoxy or phenoxyacetic acid family. Although it is classified as an herbicide, a plant growth regulator, and a fungicide, it is mainly used as a selective post emergence herbicide for the control of broadleaf weed species and aquatic weeds. 2,4-D is registered for use on pasture/rangeland, turf, wheat, corn, soybeans, fallow land, hay other than alfalfa, non-cropland (roadways, rights-of-way, ditches, industrial sites, etc.), forestry, rice, sugarcane, pome fruits, stone fruits, nut orchards, filberts, grass grown for seed and sod, aquatic weed control, potatoes, asparagus, strawberries, blueberries, grapes, cranberries, and citrus (USEPA 2005).

2,4-D is generally not applied as the acid, but is applied as one of several formulations, which quickly break down into 2,4-D acid (e.g., chemical formulations of 2,4-D amine salts and 2,4-D esters). 2,4-D mimics the effect of auxins, or other plant growth regulating hormones, and thus stimulates growth, rejuvenates old cells, and overstimulates young cells leading to abnormal growth patterns and death in some plants (Walters 1999). 2,4-D is thought to increase cell-wall plasticity, biosynthesis of proteins and the production of ethylene. The abnormal increase in these processes results in uncontrolled cell division and growth which damages vascular tissue (USEPA 2005).

4.6.4.1 Environmental Fate

In the aqueous environment, 2,4-D is most commonly found as the free anion (the amine salt formulations dissociate to the anion and ester formulations hydrolyze to the anion, usually within 1 day) (Walters 1999). The dissipation of 2,4-D is dependent on oxidative microbial-mediated mineralization, photodegradation in water, and leaching (USEPA 2005). 2,4-D has low persistence in soil, primarily due to degradation by soil microbes, and microorganisms also readily degrade 2,4-D in aquatic environments (Table 4-23). In water, 2,4-D will biodegrade at a rate dependent upon the level of nutrients present, temperature, availability of oxygen, and whether or not the water has been previously contaminated with 2,4-D or other phenoxyacetic acids (Walters 1999, Siemering 2005).

Table 4-23 Degradation of 2,4-D

Degradation Method	Half-life	Reference
Hydrolysis (water)	Stable	USEPA 2005
Hydrolysis (soil)	39 Days	Walters 1999
Photolysis (water)	12.9 to 13 Days	USEPA 2005, Walters 1999
Photolysis (soil)	68 to 393 Days	USEPA 2005, Walters 1999
Aerobic metabolism (water)	15 Days	USEPA 2005, Walters 1999
Aerobic metabolism (soil)	6.2 to 66 Days	USEPA 2005, Walters 1999
Anaerobic metabolism (water)	41 to 333 Days	USEPA 2005, Walters 1999
Field dissipation (soil)	59.3 Days	Walters 1999

4.6.4.2 Human Toxicity

The modes of toxicity to mammals from the acid, ester, and salt forms of 2,4-D are similar, although the acid and salt forms can also be eye irritants. The oral LD50 for rats ranges from 639 to 1,646 mg/kg, depending on the chemical form of 2,4-D used. All forms of 2,4-D are considered of low acute dermal toxicity. The dermal LD50 in rabbits ranges from 1,829 to >2,000 mg/kg. All forms of 2,4-D are considered of low inhalation toxicity. The inhalation LC50 for rats ranges from 0.78 to >5.4 mg/L, depending on the formulation used (Gervais et al. 2008).

In mammals, 2,4-D is actively secreted by the proximal tubules of the kidney and toxicity appears to result when renal clearance capacity is exceeded. Dose-dependent toxic effects, including damage to the eyes, thyroid, kidney, adrenals, ovaries, and testes, have been observed in rats at 15 mg/kg/day (Charles et al. 1996). Additionally, reproductive toxicity, neurotoxicity, and developmental toxicity have also been observed (Gervais et al. 2008). Because 2,4-D has been associated with effects on the thyroid and gonads following exposure, it has been included in the final list of chemicals for screening under the USEPA Endocrine Disruptor Screening Program (USEPA 2009a).

4.6.4.3 Ecological Toxicity

2,4-D is slightly to moderately toxic to birds. The LD50 is 1,000 mg/kg in mallards (EXTOXNET 1996a). The LD50 for acute oral exposure for pheasants is 472 mg/kg (Gervais et al. 2008). Some formulations are highly toxic to fish while others are less toxic. The LC50 for cutthroat trout ranges from 1.0 to 100 mg/L, depending on the formulation tested (EXTOXNET 1996a). The 24-hr LC50 for honey bees has been estimated as between 104 and 115 µg/bee and therefore 2,4-D is considered practically nontoxic to bees (USEPA 2005). 2,4-D has been shown to accumulate in fish at up to 18X the ambient concentrations within 2 days of exposure (Wang et al. 1994) as cited by (Tu et al. 2001).

4.6.4.4 Summary of Toxicity and Potential Effects

2,4-D has low persistence in soil and leaches to groundwater. 2,4-D is of low to moderate toxicity to mammals and birds; however, some formulations are highly toxic to fish and invertebrates. In addition, 2,4-D has been associated with dose-dependent damage to eyes, thyroid, kidneys, adrenals, ovaries, and testes in chronic studies of rats. It has been included in the final list of chemicals for screening under the USEPA Endocrine Disruptor Screening Program (USEPA 2009a). Although 2,4-D has been characterized as a potential candidate for the banned chemical list (based upon the high toxicity of 2,4-D to some fish, the potential of 2,4-D to runoff, and other factors), USEPA has not yet banned it based on its efficacy and documented need by agriculture and industry. Therefore, the status of 2,4, D should be monitored by the Districts for updates by the regulatory community.

In addition to the toxicity values referenced in Sections 4.6.4.2 and 4.6.4.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.6.5 Sulfometuron Methyl

Sulfometuron methyl was originally registered as a pesticide active ingredient in the U.S. in February 1982. Sulfometuron methyl is a broad-spectrum sulfonylurea herbicide recommended for preemergence and post-emergence control of annual, biennial, and perennial grasses and broadleaf weeds. The herbicide is used for general weed control on industrial noncrop sites and for selective weed control on turf grasses on industrial sites. It is also used for selective weed control in forest site preparation and in the release of several types of pines and certain hardwoods (O'dell 1999). Similar to other sulfonylurea herbicides, sulfometuron's mode of action involves inhibiting the activity of the enzyme acetolactate synthase, which inhibits the production of amino acids required for cell growth in plants (USEPA 2008c). The result is growth inhibition followed by a decline in plant vigor, discoloration, chlorosis, and terminal bud death. Although seed development is not inhibited, sulfometuron methyl effectively retards or stops root and shoot development (O'dell 1999).

4.6.5.1 Environmental Fate

Hydrolysis, photolysis and microbially-mediated degradation are major routes of transformation of sulfometuron methyl in water, soil, and water-sediment systems (Table 4-24). The degradation in soil and water appears to be enhanced in the presence of an active microbial population (aerobic and anaerobic degradation both proceed more slowly under sterile conditions) (USEPA 2008c). Sulfometuron methyl has a low tendency to sorb to sediments. Partitioning of sulfometuron methyl and its breakdown products between water and sediment is dependent on pH and organic content of the solids (O'dell 1999). Sulfometuron methyl has the potential to leach to ground water and/or reach surface water during runoff events (USEPA 2008c).

Table 4-24 Degradation of Sulfometuron methyl

Degradation Method	Half-life	Reference
Hydrolysis, pH 5	5 to 14 Days	O'dell 1999,
Hydrolysis, pH 7	>30 Days	O'dell 1999
Photolysis (water)	12 Days	O'dell 1999
Photolysis (soil)	11 Days	O'dell 1999
Aerobic metabolism (soil)	53 Days	O'dell 1999
Anaerobic metabolism (soil)	283 Days	O'dell 1999
Field dissipation (soil)	14 Days	O'dell 1999

4.6.5.2 Human Toxicity

Sulfometuron methyl is classified as Category IV to mammals for oral and inhalation toxicity and Category III for dermal toxicity by the USEPA (USEPA 2008c). The oral LD50 for rats is >5,000 mg/kg. The dermal LD50 for rabbits is >2,000 mg/kg. The inhalation LC50 for rats is >5.0 mg/L (USEPA 2008c) and greater than 11 mg/L according to MacBean (2012) (Table 6-1).

4.6.5.3 Ecological Toxicity

Sulfometuron methyl is nontoxic to birds, slightly toxic to fish, and practically nontoxic to *Daphnia* and honey bees (EXTOXNET 1996d). The avian oral LD50 is >4,650 mg/kg (MacBean 2012, reports LD50 values greater than 5000 mg/kg for both mallards and bobwhite quail). No sublethal effects have been observed during acute toxicity studies of birds (USEPA 2008c). The LC50 for fish is >100 mg/L, although MacBean (2012) reports LC50 values for bluegill and trout are greater than 12.5 mg/L. The LC50 for *Daphnia magna* is 125 mg/L (technical material) and >1,000 mg/L (dispersible granule). The 48-hr contact LC50 for honey bees is >100 µg active ingredient/bee (USEPA 2008c). Sulfometuron methyl has low potential to volatilize from soil or water or to bioaccumulate (USEPA 2008c).

Sulfometuron methyl is phytotoxic to duckweed (*Lemna gibba*) at concentrations of ≥ 0.59 µg/L but the effects appear to be reversible given sufficient recovery periods (USEPA 2008c). The chemical is toxic to a broad range of terrestrial plants. EC25 values have been established for sorghum, sugar beets, corn, and soybeans. In all cases, the most sensitive endpoints were seedling emergence and vegetative vigor (USEPA 2008c).

4.6.5.4 Summary of Toxicity and Potential Effects

Sulfometuron methyl tends to sorb to soils but has the potential to leach to groundwater. It is of low toxicity to mammals, birds, and bees. It is slightly toxic to fish. The chemical is phytotoxic to non-target aquatic plants such as duckweed. Based upon the toxicity and environmental fate of sulfometuron methyl**,** and using BMP application practices, these products should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Sections 4.6.5.2 and 4.6.5.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.6.6 Bentazon

Bentazon, also known by its trade name *Basagran*, is a selective herbicide that is used after seedlings have emerged to control broadleaf weeds and sedges among food and feed crops including alfalfa, beans, corn, peanuts, peas, peppers, peppermint, rice, sorghum, soybeans and spearmint. Bentazon also is registered for use on ornamental lawns and turf. Most bentazon used in the U.S. (73 percent) is applied to soybean crops. Based on chemical affinities, bentazon is considered a member of the thiadiazine group, containing nitrogen and sulfur atoms. It is a benzothiadiazinone contact herbicide and photosynthetic electron transport inhibitor. Bentazon is formulated and used as the sodium salt alone or in combination with atrazine (USEPA 1994c). The chemical interferes with the ability of susceptible plants to use sunlight for photosynthesis and visible injury to the plants occurs within 4 to 8 hours of application followed by death of the plant.

4.6.6.1 Environmental Fate

Dissipation of bentazon is dependent on photolysis, microbe-induced degradation, leaching and surface water runoff (Table 4-25). Degradation in aquatic environments is dependent on photolysis. Degradation in soil is controlled by processes involving microbes in the presence of oxygen. Bentazon has a low binding affinity to soil and therefore may leach into ground water and runoff into surface waters. Leaching did not appear to be a major route of dissipation in field studies, however. Bentazon dissipates rapidly under typical use conditions. The soil degradates of bentazon include 2-amino-n-isopropylbenzamide (AIBA), which is very mobile but not persistent (half-life 1 to 10 days), and N-methylbentazon which is not mobile (USEPA 1994c).

Table 4-25 Degradation of Bentazon

Degradation Method	Half-life	Reference
Hydrolysis, pH 5-9	Stable	USEPA 1994c
Photolysis (water)	2.6 Days	USEPA 1994c
Photolysis (soil)	>39 Days	USEPA 1994c
Aerobic metabolism (water)	Stable	USEPA 1994c
Aerobic metabolism (soil)	24 to 98 Days	USEPA 1994c
Anaerobic metabolism (water)	Stable	USEPA 1994c
Anaerobic metabolism (soil)	89 Days	USEPA 1994c
Field dissipation (soil)	7 to 33 Days	USEPA 1994c

4.6.6.2 Human Toxicity

Bentazon is slightly toxic (Category III) to mammals via the oral, dermal, and inhalation routes and is a skin sensitizer (USEPA 1994a, EXTOXNET 1996e). The oral LD50 for rats is 1,100 mg/kg. The dermal LD50 for rabbits is 4,000 mg/kg. Bentazon has not been associated with carcinogenic effects but causes some developmental toxicity effects in rats and rabbits (USEPA 1994a). The inhalation LC50 for rats has been reported at 5.1 mg/L (MacBean 2012).

4.6.6.3 Ecological Toxicity

Bentazon is slightly toxic to birds on an acute oral and subacute dietary basis and exceeds the level of concern for avian chronic reproductive effects. The risk to birds can be reduced by lowering the maximum seasonal application rate from four to two pounds per acre, as recommended by the USEPA (USEPA 1994a). The oral LD50 for bobwhite quail is 1,171 mg/kg. Bentazon is slightly toxic to small mammals and practically nontoxic to fish and invertebrates. MacBean (2012) reports the LC50 for bluegill and trout is greater than 100 mg/L and the EC50 for Daphnia is 125000 µg/L. The contact LD50 for bees is greater than 100 µg/bee. Bentazon poses a low risk to aquatic plants but may present a hazard to terrestrial plants (USEPA 1994a).

4.6.6.4 Summary of Toxicity and Potential Effects

Bentazon has low binding affinity to soil and leaches to groundwater or tends to runoff. Bentazon is slightly toxic or practically nontoxic to mammals, birds, and bees, fish, aquatic invertebrates, and aquatic plants. Based upon its low toxicity**,** and using BMP application practices, these products should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Sections 4.6.6.2 and 4.6.6.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.6.7 Diuron

Diuron is a substituted urea herbicide used for the control of a wide variety of annual and perennial broad leaved and grassy weeds on both crop and noncrop sites. The mechanism of herbicidal action is the inhibition of photosynthesis. It is rapidly translocated into the stems and leaves of plants. Diuron primarily acts by inhibiting the Hill reaction in photosynthesis, limiting the production of high-energy compounds like adenosine triphosphate (ATP) which are necessary for various metabolic processes. Diuron is registered

for pre- and post-emergent herbicide treatment of both crop and noncrop areas, as a mildewcide and preservative in paints and stains, and as an algaecide in commercial fish production, residential ponds and aquariums. Products containing diuron are intended for both occupational and residential uses. Occupational uses include agricultural food (such as citrus, berries, asparagus, pineapple, and oranges) and nonfood crops (such as cotton); ornamental trees, flowers, and shrubs; paints and coatings; ornamental fish ponds, and catfish production; rights-of-way and industrial sites. Residential uses include ponds, aquariums, and paints (USEPA 2003b). Diuron is one of the most commonly used pesticides in California. It is often used in rights of way (Moncada 2004).

4.6.7.1 Environmental Fate

The major route of dissipation for diuron in the environment is microbial degradation in water (Table 4-26). Diuron also degrades through photolysis in both water and soil, but at a slower rate. Sorption of diuron to soil is highly correlated with soil organic matter. However, relative to other pesticides diuron is generally considered both mobile and persistent. Diuron has the potential to leach to ground water and to contaminate surface waters (USEPA 2003b, Moncada 2004).

Table 4-26 Degradation of Diuron

Degradation Method	Half-life	Reference
Hydrolysis, pH 5-9	>1,240 Days, Stable	USEPA 2003b, Moncada 2004
Photolysis (water)	43 to 2,180 Days	USEPA 2003b, Moncada 2004
Photolysis (soil)	173 Days	USEPA 2003b, Moncada 2004
Aerobic metabolism (water)	33 Days	USEPA 2003b
Aerobic metabolism (soil)	372 Days	USEPA 2003b, Moncada 2004
Anaerobic metabolism (water)	5 Days	USEPA 2003b
Anaerobic metabolism (soil)	995 Days	USEPA 2003b, Moncada 2004
Field dissipation (soil)	73 to 134 Days	USEPA 2003b, Moncada 2004

4.6.7.2 Human Toxicity

Diuron has low acute toxicity (Category III or IV) to mammals by the oral, dermal, or inhalation exposure routes. It is not irritating to eyes or skin. Diuron is rapidly absorbed and metabolized by rats and is mostly excreted in the urine (USEPA 2003b). In mammals, metabolism occurs through hydroxylation and dealkylation (Moncada 2004). The oral LD50 for rats is 4,721 mg/kg for males and >5,000 mg/kg for females. The dermal LD50 for rabbits is >2,000 mg/kg. The inhalation LC50 is >7.0 mg/L. Diuron has been classified as a “known/likely” human carcinogen based on urinary bladder carcinomas in rats. Tumors occurred at doses >600 mg/kg/day (USEPA 2003b).

4.6.7.3 Ecological Toxicity

Diuron is slightly to practically nontoxic to birds. The oral LD50 for mallard ducks is >2,000 mg/kg (USEPA 2003b). It is practically nontoxic to honey bees (48-hr LC50 = 145 µg/bee). Diuron is moderately toxic to most aquatic organisms; however, it is highly toxic to cutthroat trout. The 96-hr LC50 for bluegill sunfish is 5.9 mg/L but only 0.71 mg/L for cutthroat (USEPA 2003b), although MacBean (2012) reports the 96-hr LC50 for rainbow trout is 14.7 mg/L. The 48-hr LC50 for *Daphnia magna* is 1.4-mg/L. The bioconcentration factor (BCF) for diuron predicted from its water solubility indicates low bioaccumulation potential (EXTOXNET 1996c).

4.6.7.4 Summary of Toxicity and Potential Effects

Diuron is mobile and persistent in soil. It leaches to groundwater and can contaminate surface waters when transported from the application areas. It is of low toxicity to mammals and birds, practically nontoxic to bees, but moderately toxic to fish and aquatic invertebrates. In spite of these specific toxicity issues, Districts, when using BMP application practices for diuron should not encounter unwanted adverse effects when maintaining adequate buffer zones and care in applications.

In addition to the toxicity values referenced in Sections 4.6.7.2 and 4.6.7.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.6.8 Benfluralin (Benefin)

Benfluralin is a pre-emergent dinitroaniline herbicide used to control grasses on commercial and residential turf. Benfluralin also has four food/feed use sites that include lettuce, alfalfa, clover, and birdsfoot trefoil. Other nonfood/nonfeed sites include nonbearing fruit and nut trees, nonbearing berries, nonbearing vineyards, turf, ornamentals, rights of way, fence rows/hedgerows, and Christmas tree plantations. Benfluralin works by inhibiting growth acts as a mitotic disruptor (USEPA 2004d).

4.6.8.1 Environmental Fate

Primary degradation pathways for benfluralin include photolysis and anaerobic metabolism in water (Table 4-27). Benfluralin has low mobility in soils. Benfluralin is of variable soil persistence with different mechanisms of degradation. Benfluralin volatilizes rapidly, but application practices and granular formulations are designed to slow volatilization (USEPA 2004d).

Table 4-27 Degradation of Benfluralin

Degradation Method	Half-life	Reference
Hydrolysis, pH 5-9	Stable	USEPA 2004b,d
Photolysis (water)	5.5 to 9.9 Hours	USEPA 2004b,d
Photolysis (soil)	12.5 Days	USEPA 2004b,d
Aerobic metabolism (soil)	20 to 86 Days	USEPA 2004b,d
Anaerobic metabolism (water)	38 Hours	USEPA 2004b,d
Anaerobic metabolism (soil)	12 Days	USEPA 2004b,d
Field dissipation (soil)	22 to 79 Days	USEPA 2004b,d

4.6.8.2 Human Toxicity

Benfluralin is classified as practically nontoxic (Category IV) to mammals by acute oral and dermal routes and low toxicity (Category III) for primary skin and eye irritation. Acute oral LD50 values for rats and mice are greater than 5000 mg/kg. The dermal LD50 for rabbits is greater than 500 mg/kg and the inhalation LC50 for rats is greater than 2.31 mg/L (MacBean 2012). The chemical is toxic to the kidneys, liver, and thyroid in longer-term studies. It has not been assessed for carcinogenicity in humans. Benfluralin is included in the final list of chemicals for screening under the USEPA Endocrine Disruptor Screening Program (USEPA 2009a).

4.6.8.3 Ecological Toxicity

Benfluralin is practically nontoxic to birds on an acute and sub-acute basis (LD50 >2,000 mg/kg), but has been associated with reproductive effects in chronic studies (USEPA 2004d). It is considered practically nontoxic to small mammals (LD50 >10,000 mg/kg) and honey bees (LD50 >10 µg/bee) but highly toxic to freshwater fish (USEPA 2004d). The LC50 for typical end-use product is <100 µg/L for bluegill sunfish and trout (MacBean 2012, USEPA 2004d). Preliminary toxicity data indicates that benfluralin is highly toxic to estuarine and marine invertebrates (USEPA 2004b). Benfluralin is considered to be bioaccumulative. The BCF for whole fish is 1580 (USEPA 2004d).

4.6.8.4 Summary of Toxicity and Potential Effects

Benfluralin has low mobility and variable persistence in soils. It volatilizes rapidly, but application methods are meant to slow volatilization. Benfluralin is practically nontoxic to mammals, birds, and bees on an acute basis. It is highly toxic to fish and aquatic invertebrates and is bioaccumulative. Additionally, benfluralin has been included in the final list of chemicals for screening under the USEPA Endocrine Disruptor Screening Program (USEPA 2009a). When benfluralin is applied to water bodies, it generally binds to sediments. It also photodegrades when exposed to sunlight, and does not persist in soil and sediments. Benfluralin does not generally leach into groundwater from soil applications due to its low mobility in soil. Benfluralin when used according to label guidelines and BMP application techniques, should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Sections 4.6.8.2 and 4.6.8.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.6.9 Oryzalin

Oryzalin is a selective, preemergent surface-applied herbicide used for control of annual grasses and small-seeded broadleaf weeds. Oryzalin is a dinitroaniline herbicide that controls weeds by disrupting the growth process during seed germination by inhibiting cell division in plants; it does not control established weeds. It is used to control annual grasses, broadleaf weeds, woody shrubs and vines in grapes, berries and orchard crops, including both fruits and nuts. It also is used on residential and commercial/industrial lawns and turf, golf course turf, ornamentals and shade trees, Christmas tree plantations, fencerows/hedgerows, nonagricultural rights-of-way, and uncultivated areas including patios, paths, paved areas and power stations. Oryzalin is used most on turf, almond orchards and grapes (USEPA 1994d).

4.6.9.1 Environmental Fate

The primary degradation pathways for oryzalin is photolysis (Table 4-28), otherwise oryzalin biodegrades slowly with a half-life of approximately 2 months. Oryzalin is not mobile under field conditions and most of the applied oryzalin either binds to soil or is fully mineralized. Oryzalin is most mobile in coarse, wet, alkaline soils with little organic matter. However, oryzalin would not be stable if it were to leach to groundwater. Anaerobic conditions below the soil surface would cause the chemical reduction of the compound (USEPA 1994d).

Table 4-28 Degradation of Oryzalin

Degradation Method	Half-life	Reference
Hydrolysis, pH 5-9	Stable	USEPA 1994d
Photolysis (water)	1.4 Hours	USEPA 1994d
Photolysis (soil)	3.9 Days	USEPA 1994d
Aerobic metabolism (water)	Moderate	USEPA 1994d
Aerobic metabolism (soil)	2.1 Months	USEPA 1994d
Anaerobic metabolism (water)	Moderate	USEPA 1994d
Field dissipation (soil)	58 to 146 Days	USEPA 1994d

4.6.9.2 Human Toxicity

Formulations include granular, wettable powder, water dispersible granules, emulsifiable concentrate, flowable concentrate, and liquid. In acute toxicity studies using laboratory animals, oryzalin is practically nontoxic by the oral route (USEPA 1994b). It is of moderate dermal and inhalation toxicity and causes slight eye irritation (USEPA 1994b). Oryzalin is generally of moderate acute toxicity, but is carcinogenic in animal studies; therefore, oryzalin has been classified as a possible human carcinogen. The oral LD50 for rats is >10,000 mg/kg. The dermal LD50 for rabbits is >2,000 mg/kg. The inhalation LC50 is >3.1 mg/L.

4.6.9.3 Ecological Toxicity

Oryzalin is slightly toxic to practically nontoxic to birds. The oral LD50 for bobwhite quail is 506.7 mg/kg. The dietary LC50 for mallard ducks is >5,000 mg/kg. Oryzalin is moderately toxic to fish and freshwater invertebrates. The 96-hr LC50 for fish is between 2.88 and 3.26 mg/L. The 48-hr LC50 for *D. magna* is 1.4-mg/L. Oryzalin is practically nontoxic to honey bees. The 48-hr contact LD50 for honey bees is >11 µg/bee (USEPA 2004c). Oryzalin does not accumulate significantly in fish. The BCF is 66.1 in whole bluegill sunfish (USEPA 2004c).

4.6.9.4 Summary of Toxicity and Potential Effects

Oryzalin is immobile in soils and is not of concern for ground or surface water contamination (USEPA 2004c). It is practically nontoxic to mammals, birds, and bees. It is moderately toxic to fish but does not accumulate in them. Oryzalin is a possible human carcinogen; however, proper personal protective equipment is thought to be sufficient to protect handlers from the chemical. Based upon the low toxicity and environmental fate of oryzalin**,** and using BMP application practices, these products should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Sections 4.6.9.2 and 4.6.9.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.6.10 DCPA

DCPA (or chlorthal dimethyl) is a pre-emergent herbicide used to control annual grasses and broadleaf weeds on ornamental turf and plants, strawberries, seeded and transplanted vegetables, cotton, and field beans. Use practice limitations prohibit applying DCPA directly to water or wetlands (swamps, bogs, marshes, and potholes) or through any type of irrigation system (USEPA 1998d). This herbicide kills germinating seeds by disrupting microtubule formation in exposed cells, causing abnormal cell division.

4.6.10.1 Environmental Fate

DCPA is stable to hydrolysis and photolysis. Biodegradation is the primary dissipation process for DCPA (Table 4-29). Under laboratory conditions, the half-life is approximately 15-30 days, but longer half-lives have been reported in the field. DCPA is not especially persistent or mobile. Volatilization from soil is also a major dissipation route for DCPA. Tetrachloroterephthalic acid (TPA or di-acid) is the only significant DCPA metabolite. TPA is unusually mobile and persistent in the field. Data suggest that TPA will leach to groundwater wherever DCPA is used, regardless of soil properties (USEPA 1998d).

Table 4-29 Degradation of DCPA

Degradation Method	Half-life	Reference
Hydrolysis, pH 5-9	Stable	USEPA 1998b,d
Photolysis (water)	Stable	USEPA 1998b,d
Photolysis (soil)	Stable	USEPA 1998b,d
Aerobic metabolism (soil)	18 to 37 Days	USEPA 1998b,d
Anaerobic metabolism (soil)	37 to 59 Days	USEPA 1998b,d
Field dissipation (soil)	44 to 126 Days	USEPA 1998b,d

4.6.10.2 Human Toxicity

DCPA has been classified as practically nontoxic for acute-oral toxicity and dermal irritation. DCPA has been classified as slightly toxic for dermal LD50, inhalation LC50, and eye sensitivity. The chemical has been classified as a possible human carcinogen based on increased incidence of thyroid tumors and liver tumors in rats (USEPA 1998b). The oral LD50 for rats is ≥ 5,000 mg/kg and has been reported by MacBean (2012) as being greater than 10,000 mg/kg. The oral LD50 for beagle dogs is >10,000 mg/kg. The dermal LD50 for rabbits is >2,000 mg/kg. The 4-hr inhalation LC50 for rats is >4.48 mg/L (USEPA 1998d). DCPA is included in the final list of chemicals for screening under the USEPA Endocrine Disruptor Screening Program (USEPA 2009a).

4.6.10.3 Ecological Toxicity

DCPA is practically nontoxic to birds on an acute basis. The oral LD50 for bobwhite quail is >2,250 mg/kg; however, DCPA is persistent enough to result in chronic exposure to birds (USEPA 1998d). It is practically nontoxic to bees (LD50 >230 µg/bee) (USEPA 1998d). DCPA is slightly toxic to practically nontoxic to fish and aquatic invertebrates. The 96-hr LC50 for rainbow trout is between 4.7 and >180 mg/L, depending on the study (MacBean 2012, USEPA 1998d).

4.6.10.4 Summary of Toxicity and Potential Effects

DCPA is not mobile in soil and has low persistence; however, the metabolite TPA is unusually mobile and persistent and will leach to groundwater. DCPA is of low acute toxicity to most receptors, but is classified as a possible human carcinogen and a possible endocrine disruptor. Despite the potential for chronic effects from DCPA exposure, its low persistence and low toxicity and using BMP application practices, DCPA applications should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Sections 4.6.10.2 and 4.6.10.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.6.11 Dithiopyr

Dithiopyr is a pre-emergent and post-emergent herbicide used for control of annual grasses and broad leaf weeds in established ornamental turf (USEPA 1991a).

4.6.11.1 Environmental Fate

Dithiopyr degrades slowly in water. Hydrolysis is not a significant route of degradation. Dithiopyr is slightly mobile to relatively immobile in soil. Photodegradation is not a significant route of degradation in soil. Volatization contributed more to dissipation than soil aerobic metabolism. Field dissipation for turf grass had a half-life of 17-61 days (USEPA 1991a).

4.6.11.2 Human Toxicity

Dithiopyr has low acute toxicity to mammals. The oral LD50 and 24-hr dermal LD50 for rats is >5,000 mg/kg. The 4-hr inhalation LC50 for rats is 5.98 mg/L (Ward 1993). The NOELs for systemic and reproductive toxicity in rats are 25 and 2,500 mg/L, respectively (Ward 1993). Dithiopyr is not known to have mutagenic or carcinogenic effects.

4.6.11.3 Ecological Toxicity

The University of California Agriculture and Natural Resources (2012) reports that no information is readily available on the potential ecological effects of dithiopyr. However, MacBean (2012), reports the following data: LD50 for bobwhite quail is greater than 2250 mg/kg, the 5-day LC50 for bobwhite quail and mallard is greater than 5620 mg/kg, the 96-hr LC50 for bluegill and carp is 0.7 mg/L, the 96-hr LC50 for trout is 0.5 mg/L, the 48-hr EC50 for Daphnia is 1100 µg/L, the 14-day LC50 for worms is greater than 1000 mg/kg, and the contact LD50 for bees is 80 µg/bee.

4.6.11.4 Summary of Toxicity and Potential Effects

Dithiopyr degrades slowly in water and is immobile in water. It is of low acute toxicity to mammals and has not been associated with carcinogenic or mutagenic effects. Little is known about the environmental impacts of dithiopyr use. However, using continuous monitoring of the literature for documented effects of dithiopyr and BMP application practices, proper application of dithiopyr should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Sections 4.6.11.2 and 4.6.11.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.6.12 Metolachlor

Metolachlor, a broad-spectrum herbicide, was first registered in 1976 for general weed control in noncrop areas. Since first registered for use on turf, it is now also registered for use on corn, cotton, peanuts, pod crops, potatoes, safflowers, sorghum, soybeans, stone fruits, tree nuts, nonbearing citrus, nonbearing grapes, cabbage, peppers (bell, chili, Cubanelle, tabasco), buffalograss, guymon bermudagrass for seed production, nurseries, hedgerows/fencerows and landscape plantings. Metolachlor's major use sites are corn, soybeans, and sorghum. Metolachlor is a chloracetanilide herbicide that inhibits seedling development (USEPA 1995). When absorbed through the roots and shoots just above the seed of the target weeds, it acts as a growth inhibitor by suppressing synthesis of chlorophyll, proteins, fatty acids and lipids, isoprenoids (including gibberellins), and flavonoids (including anthocyanins) (Rivard 2003).

4.6.12.1 Environmental Fate

Metolachlor degradation appears to be dependent on microbially-mediated and abiotic processes (Table 4-30). Metolachlor is stable to hydrolysis under normal environmental conditions, but subject to photolysis in soils (USEPA 1995). Metolachlor ethane sulfonic acid and metolachlor oxanilic acid are the two most common degradates of metolachlor (Rivard 2003). Metolachlor is moderately persistent and mobile. Extensive leaching can occur in soils with low organic carbon content, and is greatest if soil texture is coarse (Rivard 2003). Substantial amounts of metolachlor could be available for runoff to surface water for several months post-application (USEPA 1995).

Table 4-30 Degradation of Metolachlor

Degradation Method	Half-life	Reference
Hydrolysis, pH 5-9	Stable, >30 Days	USEPA 1995
Photolysis (water)	70 Days (natural sunlight), 4 Hours (artificial sunlight)	USEPA 1995
Photolysis (soil)	8 Days (natural sunlight) 37 Days (artificial sunlight)	USEPA 1995, Rivard 2003
Aerobic metabolism (water)	47 Days	USEPA 1995
Aerobic metabolism (soil)	26 to 67 Days	USEPA 1995, Rivard 2003
Anaerobic metabolism (water)	78 Days	USEPA 1995
Anaerobic metabolism (soil)	37 to 81 Days	USEPA 1995, Rivard 2003
Field dissipation (soil)	7 to 292 Days	USEPA 1995, Rivard 2003

4.6.12.2 Human Toxicity

The chemical has displayed low-level toxicity in acute tests. It is slightly toxic via the oral, dermal, and inhalation routes but is nonirritating to eyes and skin (USEPA 1995). MacBean (2012) reports the following data: acute oral LD50 for rats 1063 to 1936 mg/kg, dermal LD50 for rats is greater than 5050 mg/kg, and the inhalation LC50 is greater than 2.02 mg/L. Metolachlor is included in the final list of chemicals for screening under the USEPA Endocrine Disruptor Screening Program (USEPA 2009a).

4.6.12.3 Ecological Toxicity

Metolachlor is practically nontoxic to birds on an acute basis. The oral LD50 for mallard ducks is 4,640 mg/kg (USEPA 1995). Technical metolachlor is moderately toxic to freshwater fish. The LC50s for fish range from 3.9 to 10 mg/L. Metolachlor is slightly toxic to aquatic invertebrates (EC50 = 25.1 mg/L) (USEPA 1995). The chemical has low potential to bioaccumulate in fish with a whole fish BCF of 69X and whole body elimination after 14-days depuration (USEPA 1995).

4.6.12.4 Summary of Toxicity and Potential Effects

Metolachlor is moderately persistent in soil and mobile, potentially leaching to groundwater. It is slightly toxic to mammals and a potential endocrine disruptor. It is moderately toxic to fish and has low potential for bioaccumulation. Based upon the low toxicity**,** and using BMP application practices, these products should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Sections 4.6.12.2 and 4.6.12.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.6.13 Pendimethalin

Pendimethalin is a selective herbicide registered for control of broadleaf weeds and grassy weed species. It is used on various agricultural and nonagricultural sites in crop and noncrop areas. It is applied to soil pre-plant, pre-emergence, and post-emergence with ground and aerial equipment (USEPA 1997b). It is also used in aquatic rice culture and in nonagricultural, residential outdoor weed controls, such as grounds plantings, ornamentals, and turf grass (e.g., residential, golf course, landscape, sod farms) Pendimethalin acts as a microtubule disruptor (USEPA 1997b).

4.6.13.1 Environmental Fate

Pendimethalin dissipates in the environment by binding to soil, microbially-mediated metabolism, and volatilization (Table 4-31). Persistence decreases with increased temperature, increased moisture and decreased soil organic carbon. Pendimethalin residues are tightly bound to soil and sediment particles. Pendimethalin has a low potential to leach to ground water in most soils (USEPA 1997b).

Table 4-31 Degradation of Pendimethalin

Degradation Method	Half-life	Reference
Hydrolysis, pH 5-9	28 to >30 Days	USEPA 1997b
Hydrolysis (water with soil fungi)	10 to 11 Days	USEPA 1997b
Photolysis (water)	16.5 to 60 Days	USEPA 1997b
Photolysis (soil)	Stable	USEPA 1997b
Aerobic metabolism (soil)	42 to 1,322 Days	USEPA 1997b
Anaerobic metabolism (water)	6 to 105 Days	USEPA 1997b
Anaerobic metabolism (soil)	>60 Days	USEPA 1997b
Field dissipation (soil)	34 Days	USEPA 1997b

4.6.13.2 Human Toxicity

Pendimethalin has low acute toxicity to mammals. It is listed as Category III for oral toxicity and Category IV for dermal and inhalation exposure. It is nonirritating to skin and slightly irritating to eyes. The oral LD50 for rats is between 1,050 and 1,250 mg/kg, although MacBean (2012) reports the LD50 value being greater than 5,000 mg/kg. The dermal LD50 for rabbits is >2,000 mg/kg. The inhalation LC50 for rats is >320 mg/L. The LOEL for reproductive effects in rats is 346 mg/kg/day for male rats and 436 mg/kg/day for female rats (USEPA 1997b). Pendimethalin has been classified as a possible human carcinogen because it has caused thyroid follicular cell adenomas in rats (USEPA 1997b).

4.6.13.3 Ecological Toxicity

Pendimethalin is slightly acutely toxic to birds. The oral LD50 for mallard ducks is 1,421 mg/kg. Avian chronic toxicity studies have not yet been completed. Pendimethalin is practically nontoxic to honey bees (LD50 >49.7 µg/bee) and MacBean (2012) reports both contact and oral LD50 values are greater than 100 µg/bee. It is highly toxic to fish and has high potential to bioaccumulate in fish (USEPA 1997b). The LC50 for rainbow trout is 0.138 mg/L (technical pendimethalin) and 0.52 mg/L (formulated pendimethalin product) (USEPA 1997b). Reproductive effects to fish (reduced egg production, reduced hatch success) occur at exposure >6.3 µg/L. Technical pendimethalin is also highly toxic to aquatic invertebrates (LC50 for *D. magna* is 0.28 µg/L). The formulated product is moderately toxic to these organisms (LC50 for *D. magna* is 5.1 µg/L) (Table 6-1).

4.6.13.4 Summary of Toxicity and Potential Effects

Pendimethalin is of varying persistence in soil, depending on temperature and moisture. It is of low toxicity to mammals, birds, and bees. It is toxic to fish and aquatic invertebrates and has a potential to bioaccumulate. Pendimethalin is classified as a possible human carcinogen; however, the USEPA has determined that all uses of pendimethalin (as prescribed) will not cause unreasonable risks to humans or the environment (USEPA 1997b). Based upon this evaluation and the USEPA literature, using BMP application practices with these products should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Sections 4.6.13.2 and 4.6.13.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.7 Adjuvants

An adjuvant is any compound that is added to an herbicide or pesticide formulation or tank mix to facilitate the mixing, application or effectiveness of that herbicide. There are two primary types of adjuvants discussed in the chapter: 1) alkylphenol ethoxylates (APEs) and 2) plant-derived oils. APEs are synthetic surfactants found in detergents, cleaning products, pesticides, lubricants, hair dyes and other hair care products. The most common APEs are nonylphenol ethoxylates. Plant-derived oils (from soybeans, cottonseeds, etc.) decrease surface tension, but are less effective than other surfactants at increasing spreading, sticking, or penetration. Plant oils are generally of two types: triglycerides or methylated oils. Both of these are surfactants, as they typically enhance activity of an herbicide's active ingredient (activator adjuvant) or offset any problems associated with spray application, such as adverse water quality or wind (special purpose or utility modifiers). Activator adjuvants include surfactants, wetting agents, sticker-spreaders, and penetrants. Nonionic alkylphenol ethoxylate-based and silicone-based adjuvants are wetter/spreaders. Adjuvants can also be primarily oil-based. Oil additives function to increase herbicide absorption through plant tissues and increase spray retention. Oil adjuvants are made up of either petroleum, plant, or methylated plant or seed oils plus an emulsifier for dispersion in water (Bakke 2007).

Adjuvants are not under the same registration guidelines as are pesticides. EPA regulates the inclusion of certain ingredients in adjuvant formulations, but it does not stringently test and regulate the manufacture and use of adjuvant products (as they do for pesticides). As such, there is little information on the effects of different adjuvants, other than that provided by the manufacturer or published by the scientific community (Tu et al. 2001, Bakke 2007). CDPR does require the registration of adjuvants that are considered to increase the action of the pesticide it is used with (Bakke 2007).

The long-term fates of most adjuvants in soils and elsewhere in the environment are largely unknown, partially because of the lack of long-term monitoring data, but also because the ingredients in most adjuvants are not disclosed (Tu et al. 2001).

4.7.1 Alkylphenol Ethoxylates

Alkylphenol ethoxylates (APEs) can be used as detergents, wetting agents, dispersants, emulsifiers, solubilizers and foaming agents. Alkylphenol ethoxylates are widely in domestic detergents, pesticide formulations and industrial products. Industrial applications include pulp and paper, textiles, coatings, agricultural pesticides, lube oils and fuels, metals and plastics. Primary degradation of alkylphenol ethoxylates in the environment generates more persistent shorter chain alkylphenol ethoxylates and alkylphenols (i.e., nonylphenol, octylphenol, and mono- to triethoxylates), some of which may mimic natural hormones and disrupt endocrine function in wildlife and humans (Ying et al. 2002).

4.7.1.1 Environmental Fate

Alkylphenol ethoxylates degrade faster in the water column than in sediment. Alkylphenol ethoxylates bind strongly to aquatic particles in river and coastal environments and are persistent in sediments. Aerobic conditions further facilitate biotransformation of alkylphenol ethoxylate metabolites as compared to anaerobic conditions (Ying et al. 2002).

4.7.1.2 Human Toxicity

Nonylphenol (NP) is of low acute oral and dermal toxicity but is highly irritating and corrosive to the skin and eyes (USEPA 2010b). Depending on formulation, the APE oral LD50 for rats ranges from 600 to more than 10000 mg/kg. The dermal LD50 has been reported as 0.22 mg/kg and the inhalation LC50 as greater than 2000 mg/L for rats. Concern exists regarding the estrogen-mimicking behaviors of alkyl phenol ethoxylate (USEPA 2010b). The compounds nonylphenol (NP) and nonylphenol ethoxylate (NPE) are of particular interest and concern to the public and the EPA. NPs and NPEs are produced in large volumes and are widely used.

4.7.1.3 Ecological Toxicity

NP is persistent in the environment, moderately bioaccumulative, and extremely toxic to aquatic organisms. NPE, though less toxic than NP, is also highly toxic to fish, aquatic invertebrates, and aquatic plants (USEPA 2010b). Toxicity of APEs to aquatic organisms increases with alkyl chain length. The LC50 for trout ranges from 1.5 to 6.4 mg/l. The EC50 for daphnia ranges from 460 to 740 µg/L. An LC50 of 774 µg/L has been reported for snails. The toxicity of a variety of APEs are discussed in detail by Bakke (2003) and Staples, et al. (1998).

4.7.1.4 Summary of Toxicity and Potential Effects

APEs include a broad range of chemicals that tend to bind strongly to particulates and persist in sediments. Nonylphenol and short-chain NPEs are moderately bioaccumulative and extremely toxic to aquatic organisms. Aside from use in agricultural herbicide mixtures, APEs are commonly present in detergents, cleaners, food packaging, and cosmetics. The acute toxicity of APEs to mammals is low. They are possible estrogen-mimics. Nonylphenol has been detected in human breast milk, umbilical cord blood, and urine (USEPA 2010b).

The USEPA (USEPA 2010b) has recently recommended that this suite of chemicals be evaluated further due to their wide-spread use (past and present), persistence, and possible estrogen-mimicking behavior.

In addition to the toxicity values referenced in Sections 4.7.1.2 and 4.7.1.3, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.7.2 Polydimethylsiloxane Fluids

Most polydimethylsiloxane (PMDS) fluids are nonvolatile polymeric organosilicon materials consisting of ([CH3]2SiO) structural units. Various polydimethylsiloxane fluids ranging from low to high viscosity are used in a wide range of industrial applications, such as manufacturing textiles, paper, and leather goods and serve as antifoams, softeners, or water repellents. In consumer applications, polydimethylsiloxane fluids can be found in personal, household and automotive care products. They are used as softeners in skin care products, conditioners in hair care, additives in polish formulations, and as waterproofers and other surface treatments. Some polydimethylsiloxane materials are also sold as end products (usually in the industrial market), such as transformer dielectric fluids and heat transfer liquids (Dow Corning Corp. 1998).

4.7.2.1 Environmental Fate

Polydimethylsiloxane fluids are insoluble in water and have a high adsorption coefficient. Volatile, low molecular weight dimethyl siloxanes will evaporate into the atmosphere where they undergo indirect photolytic degradation. However, high molecular weight polydimethylsiloxanes typically sorb to particulate matter when in water and become associated with soil and sediments (Griessbach and Lehmann 1999).

Polydimethylsiloxanes degrade into lower molecular weight siloxanes and finally into dimethylsilanediol. Significant degradation to lower molecular weight compounds have been noted a few weeks after application to some soils. The actual rate and extent of degradation vary as a function of soil moisture content and clay type (Dow Corning Corp. 1998). The degradation rate of polydimethylsiloxanes is highly influenced by soil moisture. Degradation is slow on moist soils (3 percent within 6 months) but quite rapid on dry soil (50 percent within several days) (Griessbach and Lehmann 1999).

4.7.2.2 General Toxicity

Polydimethylsiloxanes are reported to be relatively nontoxic to benthic invertebrates and exhibit little bioaccumulation potential (Henry et al. 2001).

4.7.2.3 Summary of Toxicity and Potential Effects

Polydimethylsiloxanes are insoluble in water and typically sorb to particulates. Degradation time varies depending on moisture in soils. These chemicals appear to be relatively nontoxic to most organisms, but adequate toxicity data are not available. Although only limited information is available regarding the toxicity and environmental fate of polydimethylsiloxanes, using BMP application practices, these products should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Sections 4.7.2.2, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.7.3 Plant-Derived Oil and Methylated Seed Oil

Plant-derived oils, whether vegetable or fruit, can be used as adjuvants that enhance the effectiveness of herbicides or as a surfactant for the management of vectors, especially immature mosquitoes. Plant-derived oils are generally of two types: triglycerides or methylated oils. CocoBear Mosquito Larvicide Oil (also see Section 4.3.6.4) consists mostly of a modified coconut oil (75 percent or more by volume) combined with 10 percent by volume mineral oil and a very small amount of nonionic surfactant and other proprietary ingredients. This material can be used in various waterbodies such as ditches, stagnant pools, swamps, marshes, temporary rainwater pools and intermittently flooded areas, ponds, catch basins and manmade containers for the management of immature mosquitoes.

4.7.3.1 General Toxicity

Modified plant and methylated seed oil adjuvants are generally considered inert or essentially nonphytotoxic (Tu et al. 2001).Toxicity information is available for one product, Competitor™ (modified plant oil, polyethylene glycol fatty acid ester, polyoxyethylene sorbitan fatty acid ester) (Washington State Department of Agriculture 2009). The 96-hr LC50 for rainbow trout is 95 mg/L (slightly toxic). The 48-hr EC50 for daphnids is >100 mg/L (practically nontoxic) (Table 6-1).

CoCoBear has no reported significant toxicity to any receptors likely to be exposed during or after use as a larvicide. Acute oral toxicity to rats is >5000 mg/kg, acute dermal toxicity to rats is > 5050 mg/kg, and acute inhalation toxicity to rats is > 2.16 mg/L (Clarke 2014).

4.7.3.2 Summary of Toxicity and Potential Effects

Modified plant oils and methylated seed oils are essentially nontoxic to most organisms, including plants (Tu et al. 2001). Little is known of the environmental fate of these adjuvants. Although there is a paucity of toxicity and environmental fate information for these oils, using BMP application practices, these products should not result in unwanted adverse effects. The marketed products of coconut oils should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Section 4.7.3.1, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

4.7.4 Lecithin

Lecithin (phosphatidylcholine) is a commonly used amphoteric surfactant, which is derived from soybeans. Amphoteric surfactants contain both a positive and negative charge and typically function similarly to nonionic surfactants. There is little published research on the use and efficacy of amphoteric surfactants (Tu et al. 2001).

4.7.4.1 General Toxicity

Lecithin is a general term used to describe yellow-brownish fatty substances occurring in animal and plant tissues. When used with herbicide applications, lecithin acts as an amphoteric surfactant and functions similarly to nonionic surfactants (Tu et al. 2001). Toxicity information exists for the product, Liberate™ (lecithin, alcohol ethoxylate, modified plant oil) (Washington State Department of Agriculture 2009, Loveland Products Inc Liberate MSDS 2014). The male rat oral LD50 is greater than 5000 mg/kg. The dermal LD 50 for rabbits is greater than 2000 mg/kg. The 96-hr LC50 for rainbow trout is 17.6 mg/L (slightly toxic) and the 48-hr LC50 for daphnids is 9300 µg/L (moderately toxic). Little is known about the fate of lecithins in the environment or their effect on non-target organisms (Tu et al. 2001).

4.7.4.2 Summary of Toxicity and Potential Effects

Little is known about the toxicity or environmental fate of lecithins. Lecithins are naturally occurring phospholipids in biological cell membranes (Bakke 2007). Although there is limited information on these products, their natural occurrence and the use of BMP application practices should not result in unwanted adverse effects.

In addition to the toxicity values referenced in Section 4.7.4.1, several toxicity values for other species and tests are included in Table 6-1 from the "The Pesticide Manual" published by the British Crop Protection Council (BCPC) to supplement the published range of available toxicity values for the species of interest to the District.

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5 Evaluations of Active Ingredients

While the majority of the active ingredients reviewed do not suggest an unacceptable risk when used properly, some became the focus of additional discussion concerning actual use patterns and BMPs employed. The results of the assessments are based on preliminary assumptions about toxicity and mode of action derived from available information and data published by the manufacturers, researchers, and other published literature.

Using the available information about the active ingredients reviewed, there were several overarching parameters that are known to adversely impact risk. Primary factors considered include the inherent toxicity and mode of action of the chemical that can imply toxicity to non-target species. Other important factors that are considered include the possible transport and fate of the chemical in various media, the reported likely exposure routes, and documented ecological and human studies supporting the toxicity data. Several important parameters, such as the retention time (half-life) in various media are considered, but are based only on available information about regional conditions. Several pesticides received additional discussion during the nine Districts' workshop on February 20, 2013.

Using the approach discussed above, select active ingredients were identified (Table 5-1) and discussed during the workshop to supplement the information relevant to the evaluation of potential risk. Each of these pesticides exhibits at least one parameter that appears to drive potential risk.

Table 5-1 Active Ingredients Identified for Discussion

Active Ingredient	Vector	Potential Issue
Methoprene	Mosquitoes	Prevalent use; toxicity to aquatics and insects
Etofenprox	Mosquitoes	Toxicity to aquatic organisms; no synergist required
Bti	Mosquitoes	Prevalent use; public concerns
Pyrethrins	Mosquitoes/yellow jacket wasps	Prevalent use; requires synergist (PBO)
Resmethrin	Mosquitoes	Requires synergist (e.g., PBO); potential endocrine disruptor
Aliphatic solvents, Plant Oils as surfactants (e.g., coconut oil) mix	Weeds/vegetation/mosquitoes	Increases herbicide absorption through plant tissues and as a surface Newer products contain substantially lower percentage of petroleum distillate (10%). Older products exceed 90% petroleum distillates (e.g. BVA-2 Mosquito Larvicide Oil)
Permethrin	Mosquitoes/yellow jacket wasps	Toxicity to aquatic organisms; potential endocrine disruptor
Lambda-cyhalothrin	Yellow jacket wasps	Toxicity to aquatic organisms; potential to bioaccumulate
Bromadiolone	Rats	Toxicity to non-target organisms including mammals, birds, aquatics
Difethialone	Rats	Toxicity to non-target organisms including mammals, birds, aquatics
Alkylphenol ethoxylates (surfactants)	Weeds/vegetation/mosquitoes	Used as wetter spreader adjuvants to enhance efficacy of herbicides to enter plant tissue and surface water as larvicide. Toxicity to aquatic organisms; moderately bioaccumulative

Active Ingredient	Vector	Potential Issue
Glyphosate	Weeds/vegetation	Prevalent use; possible endocrine disruptor
Diuron	Weeds	Prevalent use; toxicity to freshwater fish
Benfluralin	Weeds	Toxicity to aquatics; potential for bioaccumulation/endocrine disruption

Table 5-2 Chemicals Employed for Larval Mosquito Abatement

Chemical Classification	Active Ingredient	Appendix B
Organophosphate	Temephos	Section 4.2.2
Bacterial larvicide	Bs	Section 4.3.1
Bacterial larvicide	Bti	Section 4.3.2
Bacterial larvicide	Spinosad	Section 4.3.3
Hydrocarbon ester	Methoprene	Section 4.3.4
Adjuvants / Surfactants	Alkylphenol Ethoxylate (APE)	Section 4.7.1
	Aliphatic Solvent (Mineral Oil)	Section 4.7.2
	Plant oil mix	Section 4.7.3
	Lecithin	Section 4.7.4

6 Toxicity Summary: All Active Ingredients

Toxicity information gathered from the published literature and regulatory sources is included in Table 6-1 below. The table includes information such as LD50, LC50, USEPA toxicity rating and other relevant toxicity information.

Most of the chemical active ingredients listed in Table 6-1 below, and in the narrative sections, have undergone several levels of testing to determine potential toxicity to humans, wildlife and vegetation. The intended and expected use of each chemical and its likely target and non-target receptors are usually included in the tests. While each listed chemical has had numerous toxicity values generated for a multitude of animal and plant species and human receptors, it would not be feasible to include all the possible data published for all species/receptors in Table 6-1. The values in this table have been included to represent a realistic set of potential species that might be affected by exposure to typical applications used for vector control by the Districts. Numerous additional toxicity data are available in a multitude of publications, particularly the several compendia produced by the USEPA, the European Union, Canada and the many state and national environmental regulatory agencies. (Chapter 7, References, includes a list of many of those additional sources.) As in all determinations of the potential toxic effects of a chemical, the key is the exposure to the chemical, regardless of the potential hazard (toxicity) demonstrated in laboratory tests

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Table 6-1 Toxicity Values Reported in the Literature for Active Ingredients

Active Ingredient	Mammalian Oral LD50 (mg/kg) Unless otherwise specified, values are for rats	Mammalian Dermal LD50 (mg/kg) Unless otherwise specified, values are for rabbits	Mammalian Inhalation LC50 (mg/L) Unless otherwise specified, values are for rats	USEPA Toxicity Rating	Avian LD50 (mg/kg) Unless otherwise specified, values are for mallard duck or bobwhite quail	Fish LC50 (mg/L) Unless otherwise specified, values are for rainbow trout or bluegill sunfish	Aquatic Invert EC50 (µg/L) Values are for *Daphnia* or similar species	Honeybee LD50 (µg/bee)	Other Receptors
Pyrethrins	2370 male rats 1030 female rats 273-796 mice	>1500 rats 5000 rabbits	3.4 rats	oral and dermal (III), inhalation (IV)	>5620 mallard	0.01 bluegill 0.0052 trout	12 daphnia (LC50)	0.13-0.29 contact/bee. 0.022 oral. Toxic but exhibits repellent effect	LC50 worms 47 mg/kg soil Algae EC50 >1.27 mg/L
Allethrins and *d-trans* allethrin	2150 male rats 900 female rats	2660 (allethrin) male rabbits 4390 female rabbits	>3.875 rats	oral and dermal (III), inhalation (IV)	>2000 (allethrin) >5620 (d-trans) 5620 LC50 bobwhite quail and mallard	0.134 carp	8.9 daphnia (LC50)	no clear data, likely toxic	EbC50 algae 2.9 µg/L
Phenothrin (sumithrin or d-phenothrin)	>5000 (no deaths)	>2000 (no deaths)	>2.1 (no deaths)	oral and inhalation (IV), dermal (III)	>2500 bobwhite quail	0.016 bluegill 0.0027 trout	4.3 daphnia	toxic to bees	1 year NOEL Dogs 7.1 mg/kg b.w.
Prallethrin	>640 male rats 460 female rats >300 dogs	>5000 rats	0.855 male rats 0.658 female rats	oral and dermal (III)	>2000 mallard 1171 bobwhite quail >5620 LC50 mallard and bobwhite quail	0.022 bluegill 0.012 trout	6.2 daphnia	Highly toxic to bees	EbC50 algae 2.0 mg/L NOEL (1 yr) dogs 5 mg/kg b.w.
Deltamethrin	87 - 5000 rats depending on carrier and study conditions	>2000 rats and rabbits	0.6 rats	Oral and dermal (II)	>2250 bobwhite quail >5620 LC50 bobwhite quail	0.0014 bluegill 0.00091 trout	0.56 daphnia (LC50)	0.012 contact/bee 0.023 oral	Oral LD50 dogs >300 mg/kg LC50 worms >1290 mg/kg soil EC50 algae >9.1 mg/L NOEL (2 yr) dogs 1 mg/kg b.w.
Esfenvalerate	75-88 rats	>5000 rats >2000 rabbits	2.93 rats	Oral (II)	381 bobwhite quail 5247 LC50 mallard 5620 LC50 bobwhite quail	0.00026 bluegill 0.00026 trout 0.00069 fathead minnow	0.9 daphnia	0.017 contact/bee	ErC50 algae 10 µg/L
Lambda-cyhalothrin	79 male rats 56 female rats	632 to 696 (rats)	0.06 rats	EPA (II)	>3950 mallard >5300 LC50 bobwhite quail	0.00021 bluegill 0.00036 trout	0.26 daphnia	0.038 contact/bee 0.909 oral	LC50 worms >1000 mg/kg soil ErC50 algae >1000 µg/L NOEL (1 yr) dogs 0.5 mg/kg b.w.
Resmethrin	>2500 rats	>3000 rats >2000 rabbits	>0.01 rats USEPA reports 5.28	Oral/dermal (III) Inhalation (IV)	>2000 CA quail 75 blackbird	0.017 bluegill 0.011 sheepshead minnow	3.7 daphnia (LC50)	0.015 contact/bee 0.069 oral	LC50 pink shrimp 1.3 µg/L
Tetramethrin	>5,000 rats	>2,000 rabbits	>2.73 rats	oral / dermal (IV)	>2250 bobwhite quail >5620 LC50 mallard and bobwhite quail	0.016 bluegill 0.0037 trout	110 daphnia	0.155 contact/bee	NOEL (13 wk) dogs 5000 mg/kg feeding
Permethrin	540-2690 mice 430-4000 rats	>2500 rats >2000 rabbits	>0.685 rats and mice	oral and dermal (III), inhalation (IV)	>9800 mallard >13500 Japanese quail >3000 chickens	0.0018 bluegill 0.00025 trout	0.1 (mayfly) 0.6 daphnia (LC50)	0.029 contact/bee 0.098 oral	May be toxic to cats via dermal route

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Etofenprox	>42880 rats >107200 female mice	>2,140 rats and mice	>5.9 rats	Formulation (IV)	>2000 mallard >5000 LC50 mallard and bobwhite quail	0.0033 trout 0.0085 bluegill 0.14 carp	>40000 daphnia (LC50)	0.13 contact 0.27 oral	7-day LC50 worms 43.1 ppm Oral LD50 dogs >5000 mg/kg
Piperonyl butoxide (PBO)	4570 - 7220 rats 7500 rabbits	>7950 rats 1880 rabbits	>5.9 rats	oral and dermal (III), inhalation (IV)	>2250 bobwhite quail	1.9 trout 3.94 sheepshead minnow 5.3 carp	510 to >2950 daphnia (LC50)	>25	LC50 Western Chorus Frog 0.21 mg/L LC50 Tadpole 0.21 mg/L LC50 mysid shrimp 0.49mg/L NOEL (1 yr) dogs 16 mg/kg b.w. daily
Naled	430 rats 81 - 336 (tech) rats	1100 rabbits 354 - 800 (tech) rats	>1.5 mg/L mice	formulation (I)	27-111 mallard, Canada geese, sharp-tailed grouse	0.08 trout 1.2 sheepshead minnow 2.2 bluegill 2 - 4 goldfish	0.3 daphnia	0.48 contact/bee	LC50 grass shrimp 8.9mg/L LC50 crabs 0.33 mg/L EC50 pink shrimp 5.5 µg/L
Temephos	444 rats (USEPA) 4204 male rats >10000 female rats	>4000 rats 970 - 2181 rabbits	1.3 (USEPA) 4.79 rats	oral and dermal (III), inhalation (III)	1200 LC50 mallard 170 LC50 pheasant	9.6 trout 3.49 bluegill	10 daphnia	1.55 contact/bee	no documented toxicity
Bacillus sphaericus (Bs)	>5000 rats	>2000 rabbits	>0.09 rats	Technical (III)	>9000 mallard	>15.5 bluegill & trout >100 sheepshead minnow	15500 daphnia	No effects at 10^8 spores	LC50 (30 d) worms >1000 ppm dry soil EC50 Chironomus tentans >260 mg/L EC50 oysters 42 mg/L EC50 algae >2.2 mg/L
Bacillus thuringiensis israelensis (Bti)	>1x10^{11} spores/kg rats >5000 mg/kg rats > 2 x 10^9 rabbits	>4.6x10^{10} spores/kg rats >2000 mg/kg rats >6.28 g/kg rabbits	8x10^7 spores/kg rats 2.84 rats	all acute (IV)	>3077	>600 mg/l bluegill >370 trout	>25000 daphnia (LC50)	No effects 14 day exposure	LC50 copepod >50 mg/kg
Spinosad	3783 male rats >5000 female rats	>2000 rabbits	>5.18 rats	oral and dermal (IV)	>2000 mallard & bobwhite quail >5156 LC50 mallard & bobwhite quail	5.9 bluegill 30 trout 5 carp 7.9 sheepshead minnow	14000 daphnia	0.0029 contact/bee 0.053 (tech) oral LC50	Butterfly/moth LD50 = 0.022 mg/kg. LC50 worms >1000 mg/kg soil EC50 grass shrimp >9.76 ppm No effect on amphibians, lacewings, or ladybirds.
Methoprene and s-Methoprene	>10000 rats >5050 (s-methoprene)	>2000 rabbits >5050 rabbits (s-methoprene)	210 rats >2.38 rats (s-methoprene)	oral and inhalation (IV)	>2000 mallard >4640 chickens	>0.37 bluegill 0.76 trout	89 daphnia 380 daphnia (s-methoprene)	>1000 contact/bee >1000 oral	Frog LC50 >10,000 µg/L EC50 algae 1.33 mg/L NOEL (18 mo) mice 1000 ppm

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Alcohol Ethoxylated Surfactant (monomolecular film)	>20000 rats (Agnique™)	>2000 rabbits (Agnique™)	29 rats (Agnique™)	no documented toxicity	>2000 mallard (Agnique™) >5000 LC50 bobwhite quail (Agnique™)	290 bluegill (Agnique™) 98 trout (Agnique™)	51000 daphnia (Agnique™) No observable effects to shrimp, snails, worms, or mayfly naiads	no documented toxicity	No observable effects to amphibians.
Aliphatic solvents (mineral oils, aliphatic hydrocarbons, petroleum distillates)	>28000 (no deaths observed)	>2000 rats >5,000 rabbits	3.9 rats	oral & dermal (IV) inhalation (III)	>2250 bobwhite quail and mallard	no documented toxicity	<900 daphnia	no documented toxicity	EC50 oysters 6 mg/L
Potassium Salts (soap salts) (M-Pede™ & Insecticidal Soap™, MSDS)	>5000 rats (M-Pede™ & Insecticidal Soap™)	>2000 rabbits (M-Pede™ & Insecticidal Soap™)	0.853 rat (M-Pede™)	all acute effects (IV)	no documented toxicity	no documented toxicity	no documented toxicity	no documented toxicity	no documented toxicity
Chlorophacinone	3.15 - 6.26 rats 0.329 male rabbits	200 rabbits	0.007 rats (USEPA) 0.0093 rats	all acute effects (I) oral, dermal and inhalation	258 bobwhite quail 204 LC50 mallard 95 LC50 bobwhite quail	0.62 bluegill 0.35 trout	420 daphnia (LC50)	Not toxic to bees	Carnivorous mammals LD50 = 2.1 to 50 mg/kg Worms LC50 >1000 ppm
Diphacinone	2.3 rats 50-300 mice 35 rabbits	<200 rats 3.6 rabbits	<2.0 rats	all acute effects (I)	1630 bobwhite quail 3158 mallard	7.5 bluegill 2.8 trout 2.1 catfish	1800 daphnia (LC50)	no documented toxicity	Dog oral LD50 = 3 to 7.5 mg/kg, Cat oral LD50 14.7 mg/kg, Pig oral LD50 150 mg/kg
Brodifacoum	0.418 male rats 0.21 male rabbits 0.25 - 25 large mammals	3.16 female rats 5.21 male rats	0.00305 female rats 0.00486 male rats	all acute effects (I)	11.6 Japanese quail 4.5 chickens 0.26 - 0.31 mallard 2.7 LC50 mallard	0.025 - 0.165 bluegill 0.04 - 0.05 trout	450 daphnia (LC50)	Not toxic to bees	LD50 carnivores 0.27 to 25 mg/kg LC50 worms >994 mg/kg soil ErC50 algae >0.27 mg/L
Bromadiolone	1.31 rats 1.75 mice 1.0 rabbits	23.31 rats 1.71 rabbits	<0.02 rats 0.43 µg/kg	all acute effects (I)	134 Japanese quail 138 bobwhite quail	3.0 bluegill 0.24 - 2.89 trout	5790 daphnia 8800 daphnia (LC50)	Not toxic to bees	Carnivorous mammals LD50 1.125 to 25 mg/kg LC50 worms >1054 mg/kg dry weight ErC50 algae 1.14 mg/L
Bromethalin	2.11 rats 2.38-5.6 dogs 0.54 cats	1,000 male rabbits	0.024 rats	oral and inhalation (II)	4.56 bobwhite quail	0.038 trout 0.598 bluegill	2.0	no documented toxicity	NOEL rats and dogs 0.025 mg/kg/day
Difethialone	0.56 rats 1.29 mice	7.9 male rats 5.3 female rats	0.005 -0.0193 rats	Oral and dermal (I)	0.264 bobwhite quail 0.56 LC50 bobwhite quail 1.94 LC50 mallard ducklings	0.075 bluegill 0.051 trout	4.4 daphnia	no documented toxicity	Oral LD50 dog 4 to 11.8mg/kg Oral LD 50 cat <16 mg/kg Oral LD50 pig 2 to 3 mg/kg

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Cholecalciferol (vitamin D)	43.6 rats 42.5 mice	61 male rats 185 female rats >2000 rabbits	0.13-0.38 rats	Oral and dermal (III)	>2,000 mallard >2000 bobwhite quail	no documented toxicity	no documented toxicity	no documented toxicity	Oral LD50 dog 88 mg/kg
Sulfur (fumigant)	>5000 rats	>2000 rats	>5.43 rats 2.56 rats (98% sulfur)	Oral and dermal (IV)	>5000 bobwhite quail	>180 bluegill and trout	>665000 daphnia (LC50)	nontoxic	LC50 (14 d) worms >1600 mg/L soil Nontoxic to lacewings and ladybirds
Sodium Nitrate (fumigant)	3700 rats	<2000 rats	no documented toxicity	oral (III) dermal (IV)	no documented toxicity	no documented toxicity	no documented toxicity	no documented toxicity	Nontargets in burrow susceptible.
Imazapyr	>5000 rats 4800 rabbits >2000 female mice	>2000 rabbits >2000 rats	>5.1 rats	Formulation (IV) Eye (I)	>2150 bobwhite quail >2150 mallard >5000 LC50 bobwhite quail and mallard	>100 bluegill, trout, and catfish	>100000 daphnia (LC50)	>100 contact/bee	EC50 algae 59-85 µg/L NOEL (1 yr) dogs 250 mg/kg b.w.
Glyphosate	4300 (tech) rats >5000 rats >10,000 mice 3530 goats	≥ 2000 rats (tech) ≥ 5000 rabbits (salts)	≥4.43 (tech) rats >1.3 (salts) rats	oral and dermal (III)	>2000 bobwhite quail >4640 LC50 quail and duck	86 trout 120 bluegill 130 catfish >1000 sheepshead minnow	55000 to 780000 daphnia (LC50)	>100 contact/bee	LC50 Frogs 6.6 to 18.1mg/L EC50 frogs 111 to 343mg/L
Triclopyr	577 female rats 692 male rats 630 (tech) female rats 729 (tech) male rats	>2000 rabbits	>256 rats	oral and dermal (III) inhalation (IV) TBEE	1698 (tech) mallard >5000 LC50 mallard 2935 bobwhite quail	148 bluegill 117 (tech) trout 0.36 (TBEE)-bluegill	132000 daphnia (LC50)	>100 contact/bee	EC50 algae 45 mg/L NOEL (2 yr) mice 35.7mg/kg b.w.
2,4-D (2,4-dichlorophenoxy acetic acid)	639 to 1,646 rats 138 mice	>1600 rats 1829 to 2000 rabbits	0.78 - >5.4 rats, depending on formulation	Formulation (II)	>1000 mallard 668 Japanese quail & pigeon 472 pheasant	1 to >100 trout	235000 daphnia (LC50)	104.5 oral 104 to 115 LC50	LC50 (7 d) worms 860mg/kg soil NOEL (1 yr) dogs 1mg/kg b.w. EC50 algae 33.2 mg/L
Sulfometuron methyl	>5000 male rats	>2000 rabbits	5.0 rats	oral and inhalation (IV), dermal (III)	>5000 mallard >5620 bobwhite quail	>12.5 bluegill and trout	>12500 daphnia (LC50)	>100 contact/bee	EC25 values available for many non-target plants
Bentazon	>1000 rats >750 rabbits >500 dogs and cats	>2500 rats >4000 rabbits	5.1 rats	formulation (III) oral, dermal, inhalation (III)	1140 bobwhite quail >5000 LC50 bobwhite quail and mallard	>100 bluegill >100 trout	125000 daphnia (LC50)	>100 contact/bee	EC50 worms >1000mg/kg soil NOEL (1 yr) dog 13.1mg/kg b.w. Harmless to ground beetles EC50 algae 47.3 mg/L
Diuron	>4,721 male rats >5000 female rats	>2000 rabbits	>7.0 rats	Formulation (III)	>2000 mallard 1104 bobwhite quail 5000 LC50 mallard 1730 LC50 bobwhite quail	0.71 cutthroat trout 5.9 bluegill 14 fathead minnow 14.7 rainbow trout	1400 daphnia	>145 mg/kg contact/bee	LC50 worms >400 mg/kg soil EC50 scud 0.16 mg/L EC50 brown shrimp 1.0mg/L

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Benfluralin (benefin)	>10000 rats >5000 mice >2000 dogs and rabbits	>5000 rabbits	>2.31 rats	oral & dermal (IV) formulation (II)	>2000 mallard, bobwhite quail, and chickens	0.065 bluegill 0.081 trout >1.1 sheepshead minnow	2180 daphnia (LC50)	Up to 100 ppm no effect	LC50 mysid shrimp 0.043 mg/L
Oryzalin	>10000 rats & gerbils >1000 dogs & cats	>2000 rabbits	>3.1 rats	Formulation (III)	>500 mallard and bobwhite quail >1000 chickens > 5000 LC50 mallard	2.88 bluegill 3.26 trout	1400 daphnia (LC50)	>11 contact/bee 25 oral	NOEC worms >102.6mg/kg soil
DCPA (chlorthal dimethyl) [metabolite is tetrachloroterephthalic acid (TPA)]	>10000 rats	>2000 rabbits	>4.48 rats	formulation (IV)	>2250 bobwhite quail >5620 LC50 bobwhite quail and mallard	>5.4 bluegill >4.7 trout	4600 daphnia (LC50)	>230 contact/bee	Oral LD50 10000 mg/kg dog
Dithiopyr	>5000 rats	>5,000 rats & rabbits	>5.98 rats	Formulation (III)	>2250 bobwhite quail >5620 LC50 bobwhite quail and mallard	0.7 bluegill & carp 0.5 trout	1100 daphnia (LC50)	>80 contact/bee	LC50 worms >1000mg/kg NOEL (1 yr) dogs <0.5mg/kg b.w.
Metolachlor	1936 male rats 1063 female rats	> 5050 rats	>2.02 rats	formulation (III)	>2150 bobwhite quail & mallard >10000 LC50 bobwhite quail & mallard	10 bluegill 4.9 carp 3.9 trout	25,000 daphnia (LC50)	>110 contact and oral/bee	LC50 worms 140 mg/kg soil NOEL (90 d) 300 mg/kg EC50 algae 0.1 mg/L
Pendimethalin	1050 to >5000 rats >2900 mice >5000 rabbits and dogs	>2000 rabbits	>320 rats	Oral (III) Dermal and inhalation (IV) formulation (III)	1,421 mallard 4187 LC50 bobwhite quail	0.138 – 0.89 trout 0.707 sheepshead minnow	400 daphnia 0.28 (tech) daphnia LC50 5.1 (formulation) daphnia LC50	>100 contact/bee 101.2 oral	EC50 worms >1000mg/kg soil NOEC (30 d) Chironomus riparius 0.138 mg/L EbC50 algae 0.018mg/L
Alkylphenol ethoxylate (APE)	600 to >10,000 rats	>0.22 rats	>2000 rats	low acute (III)	no documented toxicity	8.9 minnow 1.5 to 6.4 trout	460 to 740 daphnia	no documented toxicity	LC50 snails 774 µg/L
Polydimethyl-siloxane Fluids	>5000 rat	>10000 rabbit	>535 rats	no documented toxicity	no documented toxicity	no documented toxicity	>1000 mg/kg in sediment	no documented toxicity	Relatively nontoxic to benthic invertebrates.
Modified Plant Oils and Methylated Seed Oil (Competitor™ & MSO™, MSDS)	>5000 rats (Competitor™ & MSO™)	>4000 rats (MSO™) >5000 rabbits (Competitor™)	2.01 rats (MSO™)	no documented toxicity	No documented toxicity	95 rainbow trout (Competitor™)	>100 daphnia (Competitor™)	no documented toxicity	no documented toxicity
Coconut oil (MSDS COCOBEAR, >80% fatty acids 10% mineral oil)	>5000 mg/kg rats	>5050 mg/kg rats	>2.16 mg/L	No documented toxicity	>2250 mg/kg	>1000 mg/L	> 10000 mg/L microbes	no documented toxicity	no documented toxicity
Lecithin (Liberate™, MSDS)	>5000 male rat (Liberate™)	>2000 rabbit (Liberate™)	no documented toxicity	no documented toxicity	no documented toxicity	17.6 trout (Liberate™)	9300 daphnia (Liberate™)	no documented toxicity	no documented toxicity

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ATTACHMENT

A

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Table A1. Pesticide Application Data for Summer 2011 – ACMAD

Application Sites:	Agnique MMF - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Agnique MMF Comments	VectoBac G - # Treatments	Total Amount Used2	Total Amount Type3	Total Amount Unit3	VectoBac G Comments	VectoBac 12AS - # Treatments	Total Amount Used6	Total Amount Type7	Total Amount Unit7	VectoBac 12AS Comments	Altosid Liquid conc. - # Treatments	Total Amount Used11	Total Amount Type12
Canals						8	40.5	Product	Pounds									
Catchbasins						2	15	Product	Pounds		116	6.3	Product	Gallons		2	1	Product
Containers	1	0.5	Product	Ounces (volume)		3	10	Product	Pounds									
Creeks						9	51.6	Product	Pounds									
Ditches						5	12.3	Product	Pounds									
Gutters																		
Leaks						2	0.9	Product	Pounds									
Marshes, fresh						1	3	Product	Pounds									
Marshes, reclaimed						7	64	Product	Pounds									
Marshes, tidal						8	99	Product	Pounds									
Mixed CB/UV/Sumps						15	7.8	Product	Pounds									
Natural Ponds						7	43.5	Product	Pounds									
Ornamental Ponds						21	6.4	Product	Pounds									
Overwatering																		
Rainwater						4	8.1	Product	Pounds									
Sanitary																		
Seepages						14	6.7	Product	Pounds									
Spas																		
Stormdrains																		
Swimming Pools						4	3.6	Product	Pounds									
Tires																		
TreeHoles																		
Under building						1	0.6	Product	Pounds									
Vaults																		
Wells																		
Totals	1	0.5				111	373	Product	Pounds		116	6.3	Product	Gallons		2	1	Product

Table A1.

Application Sites:	Total Amount Unit12	Altosid Liquid conc. Comments	Altosid Briquets - # Treatments	Total Amount Used13	Total Amount Type14	Total Amount Unit14	Altosid Briquets Comments	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit18	BVA-2 Comments	VectoLex CG - # Treatments	Total Amount Used19	Total Amount Type20	Total Amount Unit20	VectoLex CG Comments	Pyrenone 25-5 - # Treatments
Canals			5	10.7	Product	Ounces (weight)		13	54.4	Product	Gallons		6	216.5	Product	Pounds		
Catchbasins	Ounces (volume)		11	35.4	Product	Ounces (weight)		33	20.6	Product	Gallons							
Containers													1	0.03				
Creeks			6	13.7	Product	Ounces (weight)		13	2.5	Product	Gallons		14	43.1	Product	Pounds		
Ditches			5	7.2	Product	Ounces (weight)		5	1.1	Product	Gallons		7	43.2	Product	Pounds		1
Gutters																		
Leaks													2	0.9	Product	Pounds		
Marshes, fresh								3	41.3	Product	Gallons		1	3	Product	Pounds		
Marshes, reclaimed								1	2	Product	Gallons		7	72	Product	Pounds		
Marshes, tidal																		
Mixed CB/UV/Sumps			3	4.4	Product	Ounces (weight)		5	2.7	Product	Gallons		14	3.8	Product	Pounds		
Natural Ponds			2	2.1	Product	Ounces (weight)		3	0.7	Product	Gallons		7	40.5	Product	Pounds		
Ornamental Ponds			5	10.9	Product	Ounces (weight)		9	0.2	Product	Gallons		19	6.4	Product	Pounds		
Overwatering								1	0.02	Product	Gallons							
Rainwater			1	0.2	Product	Ounces (weight)		3	4.5	Product	Gallons		4	24.1	Product	Pounds		
Sanitary			1	4.8	Product	Ounces (weight)		7	1.44	Product	Gallons		7	68	Product	Pounds		
Seepages			2	3.8	Product	Ounces (weight)		2	0.69	Product	Gallons		16	9.7	Product	Pounds		
Spas								1	0.004									
Stormdrains			1	3.8	Product	Ounces (weight)							1	5	Product	Pounds		
Swimming Pools								17	0.4	Product	Gallons		2	0.1	Product	Pounds		
Tires																		
TreeHoles																		
Under building													1	0.6	Product	Pounds		
Vaults								2	0.02									
Wells								1	0.02									
Totals	Ounces (volume)		42	97	Product	Ounces (weight)		119	132.594	Product	Gallons		109	536.93	Product	Pounds		1

Table A1.

Application Sites:	Total Amount Used29	Total Amount Type30	Total Amount Unit30	Pyrenone 25-5 Comments	Altosid XR-Briquets - # Treatments	Total Amount Used37	Total Amount Type38	Total Amount Unit38	Altosid XR-Briquets Comments	FourStar 180 Bs - # Treatments	Total Amount Used1315	Total Amount Type1416	Total Amount Unit1417	FourStar 180 Bs Comments	Natular G30 - # Treatments	Total Amount Used1924	Total Amount Type2025	Total Amount Unit2026
Canals					2	3.9	Product	Ounces (weight)		3	1.6	Product	Pounds		3	16	Product	Pounds
Catchbasins					8	37.4	Product	Ounces (weight)		11	4.8	Product	Pounds					
Containers					1	2.6	Product	Ounces (weight)		3	0.4	Product	Pounds					
Creeks					2	21.9	Product	Ounces (weight)		6	4.8	Product	Pounds		1	4	Product	Pounds
Ditches	5	Product	Ounces (volume)							4	3.4	Product	Pounds					
Gutters																		
Leaks																		
Marshes, fresh					1	7.7	Product	Ounces (weight)										
Marshes, reclaimed										2	3.1	Product	Pounds					
Marshes, tidal																		
Mixed CB/UV/Sumps					2	14.2	Product	Ounces (weight)		4	1.2	Product	Pounds					
Natural Ponds										3	1	Product	Pounds		2	21	Product	Pounds
Ornamental Ponds					13	42.5	Product	Ounces (weight)		5	0.9	Product	Pounds					
Overwatering																		
Rainwater																		
Sanitary										1	1.3	Product	Pounds					
Seepages																		
Spas										1	0.1	Product	Pounds					
Stormdrains																		
Swimming Pools					8	119.9	Product	Ounces (weight)		9	4.6	Product	Pounds					
Tires																		
TreeHoles																		
Under building										1	0.1	Product	Pounds					
Vaults					1	1.3	Product	Ounces (weight)										
Wells																		
Totals	5	Product	Ounces (volume)		38	251.4	Product	Ounces (weight)		42	27.3	Product	Pounds		109	41	Product	Pounds

Table A1.

Application Sites:	Natular G30 Comments	Natular XRT - # Treatments	Total Amount Used2127	Total Amount Type2228	Total Amount Unit2229	Natular XRT Comments	VectoLex WDG - # Treatments	Total Amount Used3345	Total Amount Type3446	Total Amount Unit3447	VectoLex WDG Comments	Altosid Pellets - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Altosid Pellets Comments	Golden Bear Oil - # Treatments	Total Amount Used
Canals		2	2.8	Product	Pounds												2	0.3
Catchbasins		69	218	Product	Pounds		168	111.6	Product	Pounds							14	2.4
Containers												4	192	Product	Ounces (weight)		5	0.8
Creeks		7	4.2	Product	Pounds							1	32	Product	Ounces (weight)			
Ditches		4	7.5	Product	Pounds												2	5
Gutters		1	0.5	Product	Pounds												1	0.2
Leaks																		
Marshes, fresh																		
Marshes, reclaimed																		
Marshes, tidal												1	240	Product	Ounces (weight)			
Mixed CB/UV/Sumps		7	3.1	Product	Pounds												4	0.3
Natural Ponds		1	1.1	Product	Pounds													
Ornamental Ponds		10	7.5	Product	Pounds												5	0.3
Overwatering												1	4	Product	Ounces (weight)			
Rainwater		1	1	Product	Pounds												1	0.001
Sanitary		4	13.9	Product	Pounds												2	0.5
Seepages		1	0.7	Product	Pounds							1	48	Product	Ounces (weight)		2	0.02
Spas																		
Stormdrains		1	1.1	Product	Pounds												1	3
Swimming Pools		16	21.1	Product	Pounds												8	0.8
Tires																		
TreeHoles																		
Under building																	4	0.1
Vaults																		
Wells		1	0.4	Product	Pounds													
Totals		125	282.9	Product	Pounds		168	111.6	Product	Pounds		8	516	Product	Ounces (weight)		51	13.721

Table A1.

Application Sites:	Total Amount Type	Total Amount Unit	Golden Bear Oil Comments	Vectolex WSP - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Vectolex WSP Comments	VectoMAX CG - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	VectoMAX CG Comments
Canals	Product	Gallons		1	1.5	Product	Pounds		3	7	Product	Pounds	
Catchbasins	Product	Gallons		23	6.1	Product	Pounds						
Containers	Product	Gallons		4	0.7	Product	Pounds						
Creeks				3	1.5	Product	Pounds		3	8	Product	Pounds	
Ditches	Product	Gallons							3	10	Product	Pounds	
Gutters	Product	Gallons		1	0.1	Product	Pounds						
Leaks													
Marshes, fresh									3	13	Product	Pounds	
Marshes, reclaimed													
Marshes, tidal													
Mixed CB/UV/Sumps	Product	Gallons		2	0.2	Product	Pounds						
Natural Ponds									1	5	Product	Pounds	
Ornamental Ponds	Product	Gallons		27	2.5	Product	Pounds						
Overwatering				2	0.2	Product	Pounds						
Rainwater				4	0.5	Product	Pounds		1	3	Product	Pounds	
Sanitary	Product	Gallons		4	1.6	Product	Pounds						
Seepages				10	0.8	Product	Pounds						
Spas													
Stormdrains	Product	Gallons		1	0.9	Product	Pounds						
Swimming Pools	Product	Gallons		10	2.4	Product	Pounds						
Tires													
TreeHoles													
Under building	Product	Gallons		3	0.7	Product	Pounds						
Vaults													
Wells													
Totals	Product	Gallons		95	19.7	Product	Pounds		11	46	Product	Pounds	

Table A2. **Pesticide Application Data for Fall 2011 – ACMAD**

Application Sites:	VectoBac G - # Treatments	Total Amount Used2	Total Amount Type3	Total Amount Unit3	VectoBac G Comments	VectoBac 12AS - # Treatments	Total Amount Used6	Total Amount Type7	Total Amount Unit7	VectoBac 12AS Comments	Altosid Briquets - # Treatments	Total Amount Used13	Total Amount Type14	Total Amount Unit14	Altosid Briquets Comments	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit18
Canals	5	45	Product	Pounds							1	2.7	Product	Ounces (weight)		4	6	Product	Gallons
Catchbasins						16	1.1	Product	Gallons		2	0.8	Product	Ounces (weight)		6	10.2	Product	Gallons
Containers	1	6	Product	Pounds															
Creeks	5	16.5	Product	Pounds												3	5	Product	Gallons
Ditches	6	83	Product	Pounds															
Gutters																			
Leaks																			
Marshes, fresh	1	10	Product	Pounds															
Marshes, reclaimed	17	261	Product	Pounds		1	0.1	Product	Gallons							7	89.1	Product	Gallons
Marshes, tidal	5	25	Product	Pounds															
Mixed CB/UV/Sumps	3	0.8	Product	Pounds															
Natural Ponds	3	9.5	Product	Pounds															
Ornamental Ponds	8	38.2	Product	Pounds							3	1.1	Product	Ounces (weight)					
Overwatering																			
Rainwater	6	48	Product	Pounds												2	2	Product	Gallons
Sanitary																1	0.2	Product	Gallons
Seepages	1	0.25	Product	Pounds							1	2.9	Product	Ounces (weight)					
Spas																			
Stormdrains											1	1	Product	Ounces (weight)					
Swimming Pools	1	0.16	Product	Pounds												1	0.02	Product	Gallons
Tires																			
TreeHoles																			
Under building	2	1	Product	Pounds							2	1.9	Product	Ounces (weight)					
Vaults																			
Wells																			
Totals	64	544.41	Product	Pounds		17	1.2	Product	Gallons		10	10.4	Product	Ounces (weight)		24	112.52	Product	Gallons

Table A2.

Application Sites:	BVA-2 Comments	VectoLex CG - # Treatments	Total Amount Used19	Total Amount Type20	Total Amount Unit20	VectoLex CG Comments	Altosid XR-Briquets - # Treatments	Total Amount Used37	Total Amount Type38	Total Amount Unit38	Altosid XR-Briquets Comments	FourStar 180 Bs - # Treatments	Total Amount Used1315	Total Amount Type1416	Total Amount Unit1417	FourStar 180 Bs Comments	Natular XRT - # Treatments
Canals		1	2	Product	Pounds												
Catchbasins																	1
Containers												1	0.1	Product	Pounds		
Creeks		1	0.5	Product	Pounds		1	2.6	Product	Ounces (weight)		1	0.3	Product	Pounds		3
Ditches		3	53	Product	Pounds												
Gutters																	
Leaks																	
Marshes, fresh		1	10	Product	Pounds												
Marshes, reclaimed		6	169	Product	Pounds												
Marshes, tidal		4	200	Product	Pounds												
Mixed CB/UV/Sumps		3	0.8	Product	Pounds		1	5.2	Product	Ounces (weight)							
Natural Ponds		2	13.5	Product	Pounds												1
Ornamental Ponds		5	4.2	Product	Pounds		3	9	Product	Ounces (weight)		1	0.1	Product	Pounds		1
Overwatering																	
Rainwater		1	9	Product	Pounds		1	2.6	Product	Ounces (weight)		2	0.6	Product	Pounds		
Sanitary		3	35	Product	Pounds												
Seepages		1	0.3	Product	Pounds												
Spas																	
Stormdrains							1	3.9	Product	Ounces (weight)							
Swimming Pools		1	0.2	Product	Pounds		2	20.6	Product	Ounces (weight)		2	0.8	Product	Pounds		4
Tires																	
TreeHoles																	
Under building		2	1	Product	Pounds												
Vaults																	
Wells																	
Totals		34	498.5	Product	Pounds		9	43.9	Product	Ounces (weight)		7	1.9	Product	Pounds		10

Table A2.

Application Sites:	Total Amount Used2127	Total Amount Type2228	Total Amount Unit2229	Natular XRT Comments	VectoLex WDG - # Treatments	Total Amount Used3345	Total Amount Type3446	Total Amount Unit3447	VectoLex WDG Comments	Golden Bear Oil - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Golden Bear Oil Comments	Vectolex WSP - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Vectolex WSP Comments
Canals															5	2.6	Product	Pounds	
Catchbasins	0.7	Product	Pounds		16	8.7	Product	Pounds		1	0.03	Product	Gallons		10	0.3	Product	Pounds	
Containers										4	0.47	Product	Gallons		3	0.1	Product	Pounds	
Creeks	1.5	Product	Pounds													0.1	Product	Pounds	
Ditches															2	0.2	Product	Pounds	
Gutters																			
Leaks																			
Marshes, fresh																			
Marshes, reclaimed					1	0.5	Product	Pounds		1	1	Product	Gallons		2	1.6	Product	Pounds	
Marshes, tidal																			
Mixed CB/UV/Sumps										4	0.21	Product	Gallons		1	1.2	Product	Pounds	
Natural Ponds	0.1	Product	Pounds																
Ornamental Ponds	0.2	Product	Pounds							5	0.02	Product	Gallons		7	0.9	Product	Pounds	
Overwatering															1	0.2	Product	Pounds	
Rainwater															2	1.2	Product	Pounds	
Sanitary															1	3.3	Product	Pounds	
Seepages																			
Spas																			
Stormdrains										1	0.02	Product	Gallons						
Swimming Pools	5.2	Product	Pounds							3	0.3	Product	Gallons		6	1.7	Product	Pounds	
Tires																			
TreeHoles																			
Under building										1	0.01	Product	Gallons		2	0.1	Product	Pounds	
Vaults																			
Wells																			
Totals	7.7	Product	Pounds		17	9.2	Product	Pounds		20	2.06	Product	Gallons		42	13.5	Product	Pounds	

Table A2.

Application Sites:	VectoMAX CG - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	VectoMAX CG Comments	Skeeter Abate - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Skeeter Abate Comments
Canals	5	5	Product	Pounds		1	10	Product	Pounds	
Catchbasins										
Containers										
Creeks	4	19	Product	Pounds						
Ditches	2	4	Product	Pounds						
Gutters										
Leaks										
Marshes, fresh	1	1	Product	Pounds						
Marshes, reclaimed										
Marshes, tidal										
Mixed CB/UV/Sumps										
Natural Ponds	1	5	Product	Pounds						
Ornamental Ponds	3	1.7	Product	Pounds						
Overwatering										
Rainwater	3	2.8	Product	Pounds		1	7	Product	Pounds	
Sanitary						1	10	Product	Pounds	
Seepages										
Spas										
Stormdrains										
Swimming Pools										
Tires										
TreeHoles										
Under building										
Vaults										
Wells										
Totals	19	38.5	Product	Pounds		3	27	Product	Pounds	

Table A3. Pesticide Application Data for Winter 2012 – ACMAD

Application Sites:	Agnique MMF - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Agnique MMF Comments	VectoBac G - # Treatments	Total Amount Used2	Total Amount Type3	Total Amount Unit3	VectoBac G Comments	VectoBac 12AS - # Treatments	Total Amount Used6	Total Amount Type7	Total Amount Unit7	VectoBac 12AS Comments	Altosid Liquid conc. - # Treatments	Total Amount Used11	Total Amount Type12	Total Amount Unit12
Canals						8	45.8	Product	Pounds										
Catchbasins																			
Containers						2	0.1	Product	Pounds										
Creeks						8	44.5	Product	Pounds										
Ditches						6	36.3	Product	Pounds		1	0.4	Product	Gallons					
Gutters																			
Leaks																			
Marshes, fresh						2	25	Product	Pounds										
Marshes, reclaimed						10	114	Product	Pounds		31	17.5	Product	Gallons		27	123.5	Product	Ounces (volume)
Marshes, tidal						9	118	Product	Pounds										
Mixed CB/UV/Sumps						6	1.6	Product	Pounds										
Natural Ponds						6	50.9	Product	Pounds		3	0.6	Product	Gallons		3	4.9	Product	Ounces (volume)
Ornamental Ponds	1	0.5	Product	Ounces (volume)		8	2.2	Product	Pounds										
Overwatering																			
Rainwater						16	117.2	Product	Pounds										
Sanitary																			
Seepages						2	4.5	Product	Pounds										
Spas																			
Stormdrains																			
Swimming Pools																			
Tires																			
TreeHoles						1	0.1	Product	Pounds										
Under building																			
Vaults																			
Wells																			
Totals	1	0.5	Product	Ounces (volume)		84	560.2	Product	Pounds		35	18.5	Product	Gallons		30	128.4	Product	Ounces (volume)

Table A3.

Application Sites:	Altosid Liquid conc. Comments	Altosid Briquets - # Treatments	Total Amount Used13	Total Amount Type14	Total Amount Unit14	Altosid Briquets Comments	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit18	BVA-2 Comments	VectoLex CG - # Treatments	Total Amount Used19	Total Amount Type20	Total Amount Unit20	VectoLex CG Comments	Altosid WSP (pellets) - # Treatments	Total Amount Used23	Total Amount Type24
Canals												7	5.8	Product	Pounds				
Catchbasins							1	0.01	Product	Gallons									
Containers		2	38.3	Product	Ounces (weight)							2	0.1	Product	Pounds				
Creeks		2	13.5	Product	Ounces (weight)		1	3	Product	Gallons		6	19.5	Product	Pounds		1	2.5	Product
Ditches		2	6.5	Product	Ounces (weight)		1	3	Product	Gallons		4	6.3	Product	Pounds		1	8.6	Product
Gutters																			
Leaks																			
Marshes, fresh							1	0.2	Product	Gallons									
Marshes, reclaimed							3	9.2	Product	Gallons		2	45	Product	Pounds				
Marshes, tidal							1	0.1	Product	Gallons		6	50	Product	Pounds		1	61.6	Product
Mixed CB/UV/Sumps		2	0.8	Product	Ounces (weight)							6	1.6	Product	Pounds				
Natural Ponds							1	1	Product	Gallons		5	11	Product	Pounds		1	12.3	Product
Ornamental Ponds		5	1.9	Product	Ounces (weight)		10	0.1	Product	Gallons		9	2.1	Product	Pounds		1	0.2	Product
Overwatering																			
Rainwater							3	9.8	Product	Gallons		11	71.1	Product	Pounds				
Sanitary							1	0.2	Product	Gallons		2	13.5	Product	Pounds				
Seepages							1	0.01	Product	Gallons		2	10.5	Product	Pounds				
Spas																			
Stormdrains																			
Swimming Pools							6	0.2	Product	Gallons									
Tires																			
TreeHoles							8	0.2	Product	Gallons		1	0.1	Product	Pounds				
Under building																			
Vaults																			
Wells																			
Totals		13	61	Product	Ounces (weight)		38	27.02	Product	Gallons		63	236.6	Product	Pounds		5	85.2	Product

Table A3.

Application Sites:	Total Amount Unit24	Altosid WSP (pellets) Commnets	Altosid XR-Briquets - # Treatments	Total Amount Used37	Total Amount Type38	Total Amount Unit38	Altosid XR-Briquets Comments	FourStar 180 Bs - # Treatments	Total Amount Used1315	Total Amount Type1416	Total Amount Unit1417	FourStar 180 Bs Comments	Natular G30 - # Treatments	Total Amount Used1924	Total Amount Type2025	Total Amount Unit2026	Natular G30 Comments
Canals																	
Catchbasins			2	14.2	Product	Ounces (weight)											
Containers			2	16.8	Product	Ounces (weight)		1	0.3	Product	Pounds						
Creeks	Ounces (weight)		1	1.3	Product	Ounces (weight)							1	0.3	Product	Pounds	
Ditches	Ounces (weight)												1	10	Product	Pounds	
Gutters																	
Leaks																	
Marshes, fresh																	
Marshes, reclaimed																	
Marshes, tidal	Ounces (weight)																
Mixed CB/UV/Sumps			1	2.6	Product	Ounces (weight)											
Natural Ponds	Ounces (weight)																
Ornamental Ponds	Ounces (weight)		7	11.6	Product	Ounces (weight)		4	1	Product	Pounds		1	0.5	Product	Pounds	
Overwatering																	
Rainwater								1	0.9	Product	Pounds						
Sanitary																	
Seepages													1	3	Product	Pounds	
Spas																	
Stormdrains																	
Swimming Pools			3	28.4	Product	Ounces (weight)		2	0.9	Product	Pounds						
Tires																	
TreeHoles																	
Under building																	
Vaults																	
Wells																	
Totals	Ounces (weight)		16	74.9	Product	Ounces (weight)		13	61	Product	Pounds		63	236.6	Product	Pounds	

Table A3.

Application Sites:	Natular XRT - # Treatments	Total Amount Used2127	Total Amount Type2228	Total Amount Unit2229	Natular XRT Comments	Altosid Pellets - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Altosid Pellets Comments	Golden Bear Oil - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Golden Bear Oil Comments	Vectolex WSP - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit
Canals																			
Catchbasins	1	0.1	Product	Pounds							1	0.3	Product	Gallons		1	0.04	Product	Pounds
Containers	1	0.4	Product	Pounds		1	0.5	Product	Ounces (weight)							3	0.3	Product	Pounds
Creeks	1	2.9	Product	Pounds		4	157	Product	Ounces (weight)										
Ditches						2	60	Product	Ounces (weight)		1	1.5	Product	Gallons					
Gutters																			
Leaks																			
Marshes, fresh																			
Marshes, reclaimed	1	1.2	Product	Pounds												3	1.3	Product	Pounds
Marshes, tidal											1	0.3	Product	Gallons		2	0.3	Product	Pounds
Mixed CB/UV/Sumps																			
Natural Ponds	1	3.7	Product	Pounds															
Ornamental Ponds	5	1.6	Product	Pounds							2	0.05	Product	Gallons		9	0.9	Product	Pounds
Overwatering																			
Rainwater						1	3	Product	Ounces (weight)							2	1	Product	Pounds
Sanitary											1	0.03	Product	Gallons		1	0.04	Product	Pounds
Seepages																3	0.3	Product	Pounds
Spas																			
Stormdrains																			
Swimming Pools	8	9.2	Product	Pounds		1	15	Product	Ounces (weight)							1	0.04	Product	Pounds
Tires																			
TreeHoles						12	18.5	Product	Ounces (weight)		3	0.7	Product	Gallons		1	0.02	Product	Pounds
Under building																			
Vaults																			
Wells																			
Totals	18	19.1	Product	Pounds		21	254	Product	Ounces (weight)		9	2.88	Product	Gallons		26	4.24	Product	Pounds

Table A3.

Application Sites:	Vectolex WSP Comments	VectoMAX CG - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	VectoMAX CG Comments
Canals		5	9	Product	Pounds	
Catchbasins						
Containers						
Creeks		2	3.5	Product	Pounds	
Ditches		2	2.5	Product	Pounds	
Gutters						
Leaks						
Marshes, fresh						
Marshes, reclaimed						
Marshes, tidal						
Mixed CB/UV/Sumps						
Natural Ponds						
Ornamental Ponds						
Overwatering						
Rainwater		1	14	Product	Pounds	
Sanitary						
Seepages		1	2	Product	Pounds	
Spas						
Stormdrains						
Swimming Pools						
Tires						
TreeHoles						
Under building						
Vaults						
Wells						
Totals		11	31	Product	Pounds	

Table A4. **Pesticide Application Data for Spring 2012 – ACMAD**

Application Sites:	Agnique MMF - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Agnique MMF Comments	VectoBac G - # Treatments	Total Amount Used2	Total Amount Type3	Total Amount Unit3	VectoBac G Comments	VectoBac 12AS - # Treatments	Total Amount Used6	Total Amount Type7	Total Amount Unit7	VectoBac 12AS Comments	Altosid Liquid conc. - # Treatments	Total Amount Used11	Total Amount Type12
Canals						10	22	Product	Pounds		1	0.6	Product	Gallons		1	4.9	Product
Catchbasins											29	0.9	Product	Gallons				
Containers						6	2.4	Product	Pounds									
Creeks						12	82.6	Product	Pounds									
Ditches						7	31	Product	Pounds		3	0.9	Product	Gallons		1	1	Product
Gutters																		
Leaks																		
Marshes, fresh						4	84.5	Product	Pounds		1	0.2	Product	Gallons				
Marshes, reclaimed						12	104.5	Product	Pounds		21	11.5	Product	Gallons		15	69.7	Product
Marshes, tidal						14	238.5	Product	Pounds		1	0.6	Product	Gallons		1	4.9	Product
Mixed CB/UV/Sumps						5	0.9	Product	Pounds									
Natural Ponds						6	35.5	Product	Pounds									
Ornamental Ponds	1	1	Product	Ounces (volume)		37	8.5	Product	Pounds									
Overwatering																		
Rainwater						18	152.7	Product	Pounds		1	0.6	Product	Gallons		1	4.9	Product
Sanitary						1	2	Product	Pounds									
Seepages						4	5.7	Product	Pounds									
Spas																		
Stormdrains																		
Swimming Pools						6	1.5	Product	Pounds									
Tires																		
TreeHoles																		
Under building																		
Vaults																		
Wells																		
Totals	1	1	Product	Ounces (volume)		142	772.3	Product	Pounds		57	15.3	Product	Gallons		19	85.4	Product

Table A4.

Application Sites:	Total Amount Unit12	Altosid Liquid conc. Comments	Altosid Briquets - # Treatments	Total Amount Used13	Total Amount Type14	Total Amount Unit14	Altosid Briquets Comments	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit18	BVA-2 Comments	VectoLex CG - # Treatments	Total Amount Used19	Total Amount Type20	Total Amount Unit20	VectoLex CG Comments	Altosid WSP (pellets) - # Treatments
Canals	Ounces (volume)		1	11	Product	Ounces (weight)		8	3.1	Product	Gallons		9	21	Product	Pounds		
Catchbasins			2	51.4	Product	Ounces (weight)		88	19.6	Product	Gallons							
Containers			1	1	Product	Ounces (weight)		4	0.1	Product	Gallons		5	2.3	Product	Pounds		
Creeks			1	9.5	Product	Ounces (weight)		6	9.4	Product	Gallons		6	21.6	Product	Pounds		
Ditches	Ounces (volume)							4	61	Product	Gallons		7	56	Product	Pounds		1
Gutters																		
Leaks																		
Marshes, fresh								1	0.2	Product	Gallons		1	4.5	Product	Pounds		
Marshes, reclaimed	Ounces (volume)							21	476.3	Product	Gallons		4	25.5	Product	Pounds		
Marshes, tidal	Ounces (volume)							2	6	Product	Gallons		1	10	Product	Pounds		
Mixed CB/UV/Sumps			3	5.9	Product	Ounces (weight)		11	15.6	Product	Gallons		5	0.9	Product	Pounds		
Natural Ponds			1	11.4	Product	Ounces (weight)		5	35.5	Product	Gallons		4	24.5	Product	Pounds		
Ornamental Ponds			4	2.3	Product	Ounces (weight)		25	2.7	Product	Gallons		24	6.3	Product	Pounds		
Overwatering																		
Rainwater	Ounces (volume)		2	5	Product	Ounces (weight)		4	6.8	Product	Gallons		11	50.2	Product	Pounds		
Sanitary								5	0.5	Product	Gallons		6	13.6	Product	Pounds		
Seepages			1	1	Product	Ounces (weight)		2	0.02	Product	Gallons		2	4.5	Product	Pounds		
Spas								2	0.01	Product	Gallons							
Stormdrains								10	0.3	Product	Gallons							
Swimming Pools			2	3.6	Product	Ounces (weight)		31	1	Product	Gallons		4	1.1	Product	Pounds		
Tires																		
TreeHoles													2	0.1	Product	Pounds		
Under building								1	0.03	Product	Gallons							
Vaults								2	0.05	Product	Gallons							
Wells																		
Totals	Ounces (volume)		18	102.1	Product	Ounces (weight)		232	638.21	Product	Gallons		91	242.1	Product	Pounds		1

Table A4.

Application Sites:	Total Amount Used23	Total Amount Type24	Total Amount Unit24	Altosid WSP (pellets) Commnets	Altosid XR-Briquets - # Treatments	Total Amount Used37	Total Amount Type38	Total Amount Unit38	Altosid XR-Briquets Comments	FourStar 180 Bs - # Treatments	Total Amount Used1315	Total Amount Type1416	Total Amount Unit1417	FourStar 180 Bs Comments	Natular G30 - # Treatments	Total Amount Used1924	Total Amount Type2025
Canals															1	12	Product
Catchbasins					17	226.8	Product	Ounces (weight)		6	2	Product	Pounds		1	1.3	Product
Containers					4	33.5	Product	Ounces (weight)									
Creeks					3	55.4	Product	Ounces (weight)							5	11.3	Product
Ditches	7.4	Product	Ounces (weight)														
Gutters																	
Leaks																	
Marshes, fresh																	
Marshes, reclaimed																	
Marshes, tidal					1	58	Product	Ounces (weight)									
Mixed CB/UV/Sumps					1	2.6	Product	Ounces (weight)		7	4.2	Product	Pounds				
Natural Ponds					1	15.5	Product	Ounces (weight)							2	14	Product
Ornamental Ponds					12	19.3	Product	Ounces (weight)		6	0.9	Product	Pounds		1	0.6	Product
Overwatering																	
Rainwater					3	24.5	Product	Ounces (weight)							1	4	Product
Sanitary										1	0.5	Product	Pounds				
Seepages															1	2	Product
Spas																	
Stormdrains					3	41.2	Product	Ounces (weight)		1	0.2	Product	Pounds				
Swimming Pools					2	19.3	Product	Ounces (weight)		4	2.4	Product	Pounds				
Tires																	
TreeHoles																	
Under building																	
Vaults					1	5.2	Product	Ounces (weight)									
Wells																	
Totals	7.4	Product	Ounces (weight)		48	501.3	Product	Ounces (weight)		18	102.1	Product	Pounds		91	242.1	Product

Table A4.

Application Sites:	Total Amount Unit2026	Natular G30 Comments	Natular XRT - # Treatments	Total Amount Used2127	Total Amount Type2228	Total Amount Unit2229	Natular XRT Comments	VectoLex WDG - # Treatments	Total Amount Used3345	Total Amount Type3446	Total Amount Unit3447	VectoLex WDG Comments	Altosid Pellets - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Altosid Pellets Comments	Golden Bear Oil - # Treatments
Canals	Pounds		6	7.7	Product	Pounds							1	48	Product	Ounces (weight)		
Catchbasins	Pounds		86	59.6	Product	Pounds		29	7.3	Product	Pounds							1
Containers			6	3.1	Product	Pounds												
Creeks	Pounds		11	25.8	Product	Pounds							4	272	Product	Ounces (weight)		
Ditches			3	1.2	Product	Pounds							1	16	Product	Ounces (weight)		
Gutters																		
Leaks																		
Marshes, fresh																		
Marshes, reclaimed			1	0.4	Product	Pounds							5	928	Product	Ounces (weight)		
Marshes, tidal													13	2744	Product	Ounces (weight)		
Mixed CB/UV/Sumps			10	12.4	Product	Pounds												
Natural Ponds	Pounds		3	3.3	Product	Pounds												
Ornamental Ponds	Pounds		34	18.3	Product	Pounds												4
Overwatering																		
Rainwater	Pounds		1	1	Product	Pounds												1
Sanitary			3	12.1	Product	Pounds												
Seepages	Pounds		3	0.4	Product	Pounds							3	3.2	Product	Ounces (weight)		
Spas			1	0.1	Product	Pounds												
Stormdrains			9	6.3	Product	Pounds												
Swimming Pools			67	66.8	Product	Pounds												
Tires																		
TreeHoles													1	1.5	Product	Ounces (weight)		1
Under building			2	1	Product	Pounds												
Vaults			2	0.2	Product	Pounds												
Wells																		
Totals	Pounds		248	219.7	Product	Pounds		29	7.3	Product	Pounds		28	4012.7	Product	Ounces (weight)		7

Table A4.

Application Sites:	Total Amount Used	Total Amount Type	Total Amount Unit	Golden Bear Oil Comments	Vectolex WSP - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Vectolex WSP Comments
Canals					2	0.8	Product	Pounds	
Catchbasins	0.01	Product	Gallons		4	5.1	Product	Pounds	
Containers					2	0.1	Product	Pounds	
Creeks									
Ditches					2	0.2	Product	Pounds	
Gutters									
Leaks									
Marshes, fresh									
Marshes, reclaimed									
Marshes, tidal									
Mixed CB/UV/Sumps					1	0.3	Product	Pounds	
Natural Ponds									
Ornamental Ponds	0.04	Product	Gallons		10	0.4	Product	Pounds	
Overwatering									
Rainwater	0.04	Product	Gallons		1	0.1	Product	Pounds	
Sanitary					1	0.1	Product	Pounds	
Seepages					3	0.2	Product	Pounds	
Spas									
Stormdrains									
Swimming Pools					2	0.3	Product	Pounds	
Tires									
TreeHoles	0.2	Product	Gallons						
Under building									
Vaults									
Wells									
Totals	0.29	Product	Gallons		28	7.6	Product	Pounds	

Table A5. Pesticide Product Key – ACMAD

Product	AI	Vector
Agnique MMF	Biodegradable Alcohol Ethoxylated Surfactant	Mosquito
Altosid Briquets	Methoprene	Mosquito
Altosid Liquid conc.	Methoprene	Mosquito
Altosid Pellets	Methoprene	Mosquito
Altosid WSP (pellets)	Methoprene	Mosquito
Altosid XR-Briquets	Methoprene	Mosquito
BVA 2	Petroleum Distillate	Mosquito
FourStar 180 Bs	Bacillus Sphaericus and Bacillus Thuringiensis Israelensis	Mosquito
Natular G30	Spinosad	Mosquito
Natular XRT	Spinosad	Mosquito
Pyrenone 25-5	Pyrethrins and Piperonyl Butoxide	Mosquito
VectoBac 12AS	Bacillus Thuringiensis Israelensis	Mosquito
VectoBac G	Bacillus Thuringiensis Israelensis	Mosquito
VectoLex CG Biologic	Bacillus Sphaericus	Mosquito
VectoLex WDG	Bacillus Sphaericus	Mosquito
VectoLex WSP	Bacillus Sphaericus	Mosquito
VectoMax CG	Bacillus Sphaericus and Bacillus Thuringiensis Israelensis	Mosquito
Golden Bear	Aliphatic Petroleum Hydrocarbons	Mosquito
Skeeter Abate	Temephos	Mosquito

Table A6. Pesticide Application Data for Summer 2011 – ACVCSD

Application Sites:	Contrac Super Blox - # Treatments	Total Amount Used4	Total Amount Type5	Total Amount Unit5	Contrac Super Blox Comments	Ditrac Tracking Powder - # Treatments	Total Amount Used43	Total Amount Type54	Total Amount Unit55	Ditrac Tracking Powder Comments
Backyard Standing Water Sources										
Rodent Burrows						1	10	Product	Ounces (weight)	
Saintary Sewers	1	246.5	Product	Pounds						
Totals	1	246.5	Product	Pounds		1	10	Product	Ounces (weight)	

Table A7. **Pesticide Application Data for Fall 2011 – ACVCSD**

Application Sites:	Contrac Super Blox - # Treatments	Total Amount Used4	Total Amount Type5	Total Amount Unit5	Contrac Super Blox Comments	Ditrac Tracking Powder - # Treatments	Total Amount Used43	Total Amount Type54	Total Amount Unit55	Ditrac Tracking Powder Comments
Backyard Standing Water Sources										
Rodent Burrows						1	12	Product	Ounces (weight)	
Saintary Sewers	1	134	Product	Pounds						
Totals	1	134	Product	Pounds		1	12	Product	Ounces (weight)	

Table A8. **Pesticide Application Data for Winter 2012 – ACVCSD**

Application Sites:	Contrac Super Blox - # Treatments	Total Amount Used4	Total Amount Type5	Total Amount Unit5	Contrac Super Blox Comments	Ditrac Tracking Powder - # Treatments	Total Amount Used43	Total Amount Type54	Total Amount Unit55	Ditrac Tracking Powder Comments
Backyard Standing Water Sources										
Rodent Burrows						1	6	Product	Ounces (weight)	
Saintary Sewers	1	15.5	Product	Pounds						
Totals	1	15.5	Product	Pounds	0	1	6	Product	Ounces (weight)	

Table A9. Pesticide Application Data for Spring 2012 – ACVCSD

Application Sites:	Altosid XR-Briquets - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Altosid XR-Briquets Comments	Contrac Super Blox - # Treatments	Total Amount Used4	Total Amount Type5	Total Amount Unit5	Contrac Super Blox Comments	Ditrac Tracking Powder - # Treatments	Total Amount Used43	Total Amount Type54	Total Amount Unit55	Ditrac Tracking Powder Comments
Backyard Standing Water Sources	1	3	Product	Ounces (weight)											
Rodent Burrows											1	13	Product	Ounces (weight)	
Saintary Sewers						1	672.5	Product	Pounds						
Totals	1	3	Product	Ounces (weight)		1	672.5	Product	Pounds		1	13	Product	Ounces (weight)	

Table A10. Pesticide Product Key – ACVCSD

Product	AI	Vector
Altosid XR-Briquets	Methoprene	Mosquito
Ditrac Tracking Powder	Diphacinone	Rat
Contrac Super Blox	Bromadiolone	Rat

Table A11. **Pesticide Application Data for Summer 2011 – CCMVCD**

Application Sites:	Agnique MMF - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Agnique MMF Comments	VectoBac G - # Treatments	Total Amount Used2	Total Amount Type3	Total Amount Unit3	VectoBac G Comments	VectoBac 12AS - # Treatments	Total Amount Used6	Total Amount Type7	Total Amount Unit7	VectoBac 12AS Comments
Canals															
Containers	6	5.09	Product	Ounces (volume)							26	14.65	Active Ingredient	Ounces (weight)	
Creeks	1	1.16	Product	Ounces (volume)		1	2.5	Product	Pounds		382	88.5	Active Ingredient	Ounces (volume)	
Ditches															
Intermittent	1	0.18	Product	Ounces (volume)							28	1368.37	Active Ingredient	Ounces (volume)	
Marshes						1	12	Product	Pounds		12	624	Active Ingredient	Ounces (volume)	
Natural Ponds						1	10	Product	Pounds		31	27.22	Active Ingredient	Ounces (volume)	
Ornamental Ponds															
Other															
Parks/Landscape															
Rainwater															
Sanitary															
Seepages															
Swimming Pools	22	12.78	Product	Ounces (volume)							46	8.41	Active Ingredient	Ounces (volume)	
Tires															
TreeHoles															
Urban Underground Water	2	5.3	Product	Ounces (volume)							15	2.01	Active Ingredient	Ounces (volume)	
Waterfront															
Wells															
Totals	32	24.51	Product	Ounces (volume)		3	24.5	Product	Pounds		540	2133.16	Active Ingredient	Ounces (volume)	

Table A11.

Application Sites:	Altosid Liquid conc. - # Treatments	Total Amount Used11	Total Amount Type12	Total Amount Unit12	Altosid Liquid conc. Comments	Altosid Briquets - # Treatments	Total Amount Used13	Total Amount Type14	Total Amount Unit14	Altosid Briquets Comments	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit18	BVA-2 Comments
Canals															
Containers						28	3.42	Product	Ounces (volume)		45	398.98	Product	Ounces (volume)	
Creeks	11	0.54	Active Ingredient	Ounces (volume)		3	0.33	Product	Ounces (volume)		49	4119.53	Product	Ounces (volume)	
Ditches															
Intermittent	22	141.19	Active Ingredient	Ounces (volume)							51	90039	Product	Ounces (volume)	
Marshes	11	48	Active Ingredient	Ounces (volume)							3	146	Product	Ounces (volume)	
Natural Ponds	4	0.064				4	0.27	Product	Ounces (volume)		11	183	Product	Ounces (volume)	
Ornamental Ponds															
Other															
Parks/Landscape											1	6	Product	Ounces (volume)	
Rainwater															
Sanitary						1	0.03	Product	Ounces (volume)		3	130	Product	Ounces (volume)	
Seepages															
Swimming Pools	10	0.1	Active Ingredient	Ounces (volume)		2	0.27	Product	Ounces (volume)		30	73.25	Product	Ounces (volume)	
Tires															
TreeHoles															
Urban Underground Water	2	0.005				28	10.44	Product	Ounces (volume)		89	4283.49	Product	Ounces (volume)	
Waterfront															
Wells															
Totals	60	189.899	Active Ingredient	Ounces (volume)		66	14.76	Product	Ounces (volume)		282	99379.25	Product	Ounces (volume)	

Table A11.

Application Sites:	VectoLex CG - # Treatments	Total Amount Used19	Total Amount Type20	Total Amount Unit20	VectoLex CG Comments	Altosid WSP (pellets) - # Treatments	Total Amount Used23	Total Amount Type24	Total Amount Unit24	Altosid WSP (pellets) Commnets	FourStar SR Briquet - # Treatments	Total Amount Used27	Total Amount Type28	Total Amount Unit28
Canals														
Containers	21	563.73	Product	Ounces (volume)		10	9.12	Product	Ounces (volume)		8	18	Product	Ounces (volume)
Creeks	67	1404.98	Product	Ounces (volume)		8	3.36	Product	Ounces (volume)		6	12.9	Product	Ounces (volume)
Ditches														
Intermittent	7	880.18	Product	Ounces (volume)							1	1.1	Product	Ounces (volume)
Marshes	2	288	Product	Ounces (volume)										
Natural Ponds	34	2866.1	Product	Ounces (volume)		1	1.44	Product	Ounces (volume)		2	8.8	Product	Ounces (volume)
Ornamental Ponds														
Other														
Parks/Landscape														
Rainwater														
Sanitary											1	9.9	Product	Ounces (volume)
Seepages														
Swimming Pools	42	38.92	Product	Ounces (volume)										
Tires														
TreeHoles														
Urban Underground Water						8	3.36	Product	Ounces (volume)		31	549.4	Product	Ounces (volume)
Waterfront														
Wells														
Totals	173	6041.91	Product	Ounces (volume)		27	17.28	Product	Ounces (volume)		49	600.1	Product	Ounces (volume)

Table A11.

Application Sites:	FourStar SR Briquet Comments	Bell Contrac Super-Size Blox - # Treatments	Total Amount Used35	Total Amount Type36	Total Amount Unit36	Bell Contrac Super-Size Blox Comments	Altosid XR-Briquets - # Treatments	Total Amount Used37	Total Amount Type38	Total Amount Unit38	Altosid XR-Briquets Comments	Drione - # Treatments	Total Amount Used1112
Canals													
Containers							27	156	Product	Ounces (volume)		2	1.5
Creeks		43	344	Product	Ounces (volume)		6	21	Product	Ounces (volume)			
Ditches													
Intermittent							1	3	Product	Ounces (volume)			
Marshes													
Natural Ponds							12	27	Product	Ounces (volume)			
Ornamental Ponds													
Other													
Parks/Landscape		23	184	Product	Ounces (volume)							682	855.55
Rainwater													
Sanitary		84	1360	Product	Ounces (volume)								
Seepages													
Swimming Pools							17	37.5	Product	Ounces (volume)			
Tires													
TreeHoles													
Urban Underground Water							133	2365.5	Product	Ounces (volume)			
Waterfront		10	88	Product	Ounces (volume)								
Wells													
Totals		160	1976	Product	Ounces (volume)		196	2610	Product	Ounces (volume)		684	857.05

Table A11.

Application Sites:	Total Amount Type1213	Total Amount Unit1214	Drione Comments	Natular 2EC - # Treatments	Total Amount Used1721	Total Amount Type1822	Total Amount Unit1823	Natular 2EC Comments	Pyrocide 7396 - # Treatments	Total Amount Used2939	Total Amount Type3040	Total Amount Unit3041	Pyrocide 7396 Comments	VectoLex CG Biologic - # Treatments
Canals														
Containers	Product	Ounces (volume)												21
Creeks														67
Ditches														
Intermittent														7
Marshes				5	360	Product	Ounces (volume)							2
Natural Ponds														34
Ornamental Ponds														
Other									28	1871.18	Product	Ounces (volume)		
Parks/Landscape	Product	Ounces (volume)												
Rainwater														
Sanitary														
Seepages														
Swimming Pools														42
Tires														
TreeHoles														
Urban Underground Water														
Waterfront														
Wells														
Totals	Product	Ounces (volume)		5	360	Product	Ounces (volume)		28	1871.18	Product	Ounces (volume)		173

Table A11.

Application Sites:	Total Amount Used3142	Total Amount Type3243	Total Amount Unit3244	VectoLex CG Biologic Comments	VectoLex WDG - # Treatments	Total Amount Used3345	Total Amount Type3446	Total Amount Unit3447	VectoLex WDG Comments	Ditrac Blox - # Treatments	Total Amount Used3	Total Amount Type	Total Amount Unit4	Ditrac Blox Comments	Vectolex WSP - # Treatments
Canals															
Containers	563.73	Product	Ounces (volume)												3
Creeks	1404.98	Product	Ounces (volume)		3	1.5	Active Ingredient	Ounces (volume)		28	448	Product	Ounces (volume)		7
Ditches															
Intermittent	880.18	Product	Ounces (volume)		1	160	Active Ingredient	Ounces (volume)							
Marshes	288	Product	Ounces (volume)												
Natural Ponds	2866.1	Product	Ounces (volume)												2
Ornamental Ponds															
Other															
Parks/Landscape										12	192	Product	Ounces (volume)		
Rainwater															
Sanitary															
Seepages															
Swimming Pools	38.92	Product	Ounces (volume)												3
Tires															
TreeHoles															
Urban Underground Water					43	94.27	Product	Ounces (volume)							8
Waterfront															
Wells															
Totals	6041.91	Product	Ounces (volume)		47	255.77	Product	Ounces (volume)		40	640	Product	Ounces (volume)		23

Table A11.

Application Sites:	Total Amount Used5	Total Amount Type6	Total Amount Unit8	Vectolex WSP Comments	Altosid Pellets - # Treatments	Total Amount Used	Total Amount Type9	Total Amount Unit	Altosid Pellets - Comments
Canals									
Containers	17.48	Product	Ounces (volume)		4	40.36	Product	Ounces (volume)	
Creeks	12.16	Product	Ounces (volume)		38	1307.82	Product	Ounces (volume)	
Ditches									
Intermittent					60	6919.61	Product	Ounces (volume)	
Marshes					33	1632	Product	Ounces (volume)	
Natural Ponds	2.28	Product	Ounces (volume)		16	768	Product	Ounces (volume)	
Ornamental Ponds									
Other									
Parks/Landscape					2	9	Product	Ounces (volume)	
Rainwater									
Sanitary					2	56	Product	Ounces (volume)	
Seepages									
Swimming Pools	7.6	Product	Ounces (volume)						
Tires									
TreeHoles									
Urban Underground Water	225.72	Product	Ounces (volume)		1	0.55	Active Ingredient	Ounces (volume)	
Waterfront									
Wells									
Totals	265.24	Product	Ounces (volume)		156	10733.34	Mix	Ounces (volume)	

Table A12. **Pesticide Application Data for Fall 2011 – CCMVCD**

Application Sites:	Agnique MMF - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Agnique MMF Comments	VectoBac G - # Treatments	Total Amount Used2	Total Amount Type3	Total Amount Unit3	VectoBac G Comments	VectoBac 12AS - # Treatments	Total Amount Used6	Total Amount Type7	Total Amount Unit7	VectoBac 12AS Comments
Canals															
Containers	5	14.72	Product	Ounces (volume)		2	28	Product	Ounces (volume)		11	2.51	Active Ingredient	Ounces (volume)	
Creeks	2	1	Product	Ounces (volume)		2	64	Product	Ounces (volume)		81	8.48	Active Ingredient	Ounces (volume)	
Ditches															
Intermittent	1	5	Product	Ounces (volume)							4	209.34	Active Ingredient	Ounces (volume)	
Marshes															
Natural Ponds						3	272	Product	Ounces (volume)		6	5.28	Active Ingredient	Ounces (volume)	
Ornamental Ponds															
Other															
Park/Landscape	1	0.25	Product	Ounces (volume)											
Rainwater															
Sanitary	1	15	Product	Ounces (volume)											
Seepages															
Swimming Pools	10	7.35	Product	Ounces (volume)							17	2.93	Active Ingredient	Ounces (volume)	
Tires															
TreeHoles															
Urban Underground Water											6	1.05	Active Ingredient	Ounces (volume)	
Waterfront															
Wells															
Totals	20	43.32	Product	Ounces (volume)		7	364	Product	Ounces (volume)		125	229.59	Active Ingredient	Ounces (volume)	

Table A12.

Application Sites:	Altosid Liquid conc. - # Treatments	Total Amount Used11	Total Amount Type12	Total Amount Unit12	Altosid Liquid conc. Comments	Altosid Briquets - # Treatments	Total Amount Used13	Total Amount Type14	Total Amount Unit14	Altosid Briquets Comments	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit18
Canals														
Containers	1	0.0023	Active Ingredient	Ounces (volume)		8	1.77	Product	Ounces (volume)		16	193.09	Product	Ounces (volume)
Creeks	9	0.1	Active Ingredient	Ounces (volume)		1	0.06	Product	Ounces (volume)		16	2431	Product	Ounces (volume)
Ditches														
Intermittent	4	21.66	Active Ingredient	Ounces (volume)							6	9354	Product	Ounces (volume)
Marshes											3	5121	Product	Ounces (volume)
Natural Ponds	1	0.007	Active Ingredient	Ounces (volume)		2	0.12	Product	Ounces (volume)		8	439.8	Product	Ounces (volume)
Ornamental Ponds														
Other														
Park/Landscape						2	0.93	Product	Ounces (volume)					
Rainwater														
Sanitary											1	384	Product	Ounces (volume)
Seepages														
Swimming Pools	8	0.06	Active Ingredient	Ounces (volume)		9	0.72	Product	Ounces (volume)		7	25	Product	Ounces (volume)
Tires														
TreeHoles														
Urban Underground Water						7	6.72	Product	Ounces (volume)		22	1024.1	Product	Ounces (volume)
Waterfront														
Wells														
Totals	23	21.8293	Active Ingredient	Ounces (volume)		29	10.32	Product	Ounces (volume)		79	18971.99	Product	Ounces (volume)

Table A12.

Application Sites:	BVA-2 Comments	VectoLex CG - # Treatments	Total Amount Used19	Total Amount Type20	Total Amount Unit20	VectoLex CG Comments	Altosid WSP (pellets) - # Treatments	Total Amount Used23	Total Amount Type24	Total Amount Unit24	Altosid WSP (pellets) Commnets	FourStar SR Briquet - # Treatments	Total Amount Used27	Total Amount Type28
Canals														
Containers		20	352.93	Product	Ounces (volume)		9	9.84	Product	Ounces (volume)		2	2.2	Product
Creeks		24	428.94	Product	Ounces (volume)		1	0.24	Product	Ounces (volume)		1	1.1	Product
Ditches														
Intermittent		3	176.36	Product	Ounces (volume)									
Marshes														
Natural Ponds		17	1266.82	Product	Ounces (volume)		2	3.84	Product	Ounces (volume)				
Ornamental Ponds														
Other														
Park/Landscape														
Rainwater														
Sanitary														
Seepages														
Swimming Pools		33	23.75	Product	Ounces (volume)		1	0.48	Product	Ounces (volume)		1	1.1	Product
Tires														
TreeHoles														
Urban Underground Water		1	1.85	Product	Ounces (volume)		2	0.96	Product	Ounces (volume)		17	317.9	Product
Waterfront														
Wells														
Totals		98	2250.65	Product	Ounces (volume)		15	15.36	Product	Ounces (volume)		21	322.3	Product

Table A12.

Application Sites:	Total Amount Unit28	FourStar SR Briquet Comments	Bell Contrac Super-Size Blox - # Treatments	Total Amount Used35	Total Amount Type36	Total Amount Unit36	Bell Contrac Super-Size Blox Comments	Altosid XR-Briquets - # Treatments	Total Amount Used37	Total Amount Type38	Total Amount Unit38	Bell Contrac Small Blox - # Treatments
Canals												
Containers	Ounces (volume)							15	60	Product	Ounces (volume)	
Creeks	Ounces (volume)		30	248	Product	Ounces (volume)						15
Ditches												
Intermittent												
Marshes												
Natural Ponds								2	9	Product	Ounces (volume)	
Ornamental Ponds												
Other												
Park/Landscape			24	192	Product	Ounces (volume)						7
Rainwater												
Sanitary			43	528	Product	Ounces (volume)						
Seepages												
Swimming Pools	Ounces (volume)							24	54	Product	Ounces (volume)	
Tires												
TreeHoles												
Urban Underground Water	Ounces (volume)							12	180	Product	Ounces (volume)	
Waterfront			11	88	Product	Ounces (volume)						2
Wells												
Totals	Ounces (volume)		108	1056	Product	Ounces (volume)		53	303	Product	Ounces (volume)	24

Table A12.

Application Sites:	Total Amount Used69	Total Amount Type710	Total Amount Unit711	Bell Contrac Small Blox Comments	Drione - # Treatments	Total Amount Used1112	Total Amount Type1213	Total Amount Unit1214	Drione Comments	Bell Terad 3 Blox - # Treatments	Total Amount Used1315	Total Amount Type1416	Total Amount Unit1417	Bell Terad 3 Blox Comments
Canals														
Containers														
Creeks	16	Product	Ounces (volume)							8	8	Product	Ounces (volume)	
Ditches														
Intermittent														
Marshes														
Natural Ponds														
Ornamental Ponds														
Other														
Park/Landscape	7	Product	Ounces (volume)		107	146.75	Product	Ounces (volume)		5	5	Product	Ounces (volume)	
Rainwater														
Sanitary														
Seepages														
Swimming Pools														
Tires														
TreeHoles														
Urban Underground Water														
Waterfront	2	Product	Ounces (volume)							2	2	Product	Ounces (volume)	
Wells														
Totals	25	Product	Ounces (volume)		107	146.75	Product	Ounces (volume)		15	15	Product	Ounces (volume)	

Table A12.

Application Sites:	First Strike - # Treatments	Total Amount Used1518	Total Amount Type1619	Total Amount Unit1620	First Strike Comments	Natular 2EC - # Treatments	Total Amount Used1721	Total Amount Type1822	Total Amount Unit1823	Natular 2EC Comments	Pyrocide 7396 - # Treatments	Total Amount Used2939	Total Amount Type3040	Total Amount Unit3041
Canals														
Containers														
Creeks	6	6	Product	Ounces (volume)										
Ditches														
Intermittent														
Marshes														
Natural Ponds														
Ornamental Ponds														
Other											1	6	Product	Ounces (volume)
Park/Landscape	5	5.6	Product	Ounces (volume)										
Rainwater														
Sanitary														
Seepages														
Swimming Pools						1	0.027	Product	Ounces (volume)					
Tires														
TreeHoles														
Urban Underground Water														
Waterfront														
Wells														
Totals	11	11.6	Product	Ounces (volume)		1	0.027	Product	Ounces (volume)		1	6	Product	Ounces (volume)

Table A12.

Application Sites:	Pyrocide 7396 Comments	VectoLex CG Biologic - # Treatments	Total Amount Used3142	Total Amount Type3243	Total Amount Unit3244	VectoLex CG Biologic Comments	VectoLex WDG - # Treatments	Total Amount Used3345	Total Amount Type3446	Total Amount Unit3447	VectoLex WDG Comments	Ditrac Blox - # Treatments	Total Amount Used3	Total Amount Type
Canals														
Containers		20	352.93	Product	Ounces (volume)									
Creeks		24	428.94	Product	Ounces (volume)							20	320	Product
Ditches														
Intermittent		3	176.36	Product	Ounces (volume)		3	480	Active Ingredient	Ounces (volume)				
Marshes														
Natural Ponds		17	1266.82	Product	Ounces (volume)									
Ornamental Ponds														
Other														
Park/Landscape												5	80	Product
Rainwater														
Sanitary														
Seepages														
Swimming Pools		33	23.75	Product	Ounces (volume)									
Tires														
TreeHoles														
Urban Underground Water		1	1.85	Product	Ounces (volume)									
Waterfront														
Wells														
Totals		98	2250.65	Product	Ounces (volume)		3	480	Active Ingredient	Ounces (volume)		25	400	Product

Table A12.

Application Sites:	Total Amount Unit4	Ditrac Blox Comments	Vectolex WSP - # Treatments	Total Amount Used5	Total Amount Type6	Total Amount Unit8	Vectolex WSP Comments	Altosid Pellets - # Treatments	Total Amount Used	Total Amount Type9	Total Amount Unit	Altosid Pellets - Comments
Canals												
Containers			10	55.48	Product	Ounces (volume)		1	10	Product	Ounces (volume)	
Creeks	Ounces (volume)		2	3.04	Product	Ounces (volume)		5	102	Product	Ounces (volume)	
Ditches												
Intermittent								7	165	Product	Ounces (volume)	
Marshes								2	32	Product	Ounces (volume)	
Natural Ponds								3	57	Product	Ounces (volume)	
Ornamental Ponds												
Other												
Park/Landscape	Ounces (volume)											
Rainwater												
Sanitary												
Seepages												
Swimming Pools			2	3.8	Product	Ounces (volume)						
Tires												
TreeHoles												
Urban Underground Water			8	23.56	Product	Ounces (volume)		1	1	Product	Ounces (volume)	
Waterfront												
Wells												
Totals	Ounces (volume)		22	85.88	Product	Ounces (volume)		19	367	Product	Ounces (volume)	

Table A13. Pesticide Application Data for Winter 2012 – CCMVCD

Application Sites:	Agnique MMF - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Agnique MMF Comments	VectoBac G - # Treatments	Total Amount Used2	Total Amount Type3	Total Amount Unit3	VectoBac G Comments	Agnique MMF G - # Treatments	Total Amount Used4	Total Amount Type5	Total Amount Unit5	Agnique MMF G Comments
Canals															
Containers															
Creeks						2	80	Product	Ounces (volume)						
Ditches															
Intermittent															
Marshes															
Natural Ponds						2	512	Product	Ounces (volume)		1	56	Product	Ounces (volume)	
Ornamental Ponds															
Park/Landscape															
Rainwater															
Sanitary															
Seepages															
Swimming Pools	9	5.06	Product	Ounces (volume)											
Tires															
TreeHoles															
Urban Underground Water															
Waterfront															
Wells															
Totals	9	5.06	Product	Ounces (volume)		4	592	Product	Ounces (volume)		1	56	Product	Ounces (volume)	

Table A13.

Application Sites:	VectoBac 12AS - # Treatments	Total Amount Used6	Total Amount Type7	Total Amount Unit7	VectoBac 12AS Comments	Altosid Liquid conc. - # Treatments	Total Amount Used11	Total Amount Type12	Total Amount Unit12	Altosid Liquid conc. Comments	Altosid Briquets - # Treatments	Total Amount Used13	Total Amount Type14	Total Amount Unit14	Altosid Briquets Comments
Canals															
Containers	3	0.63	Active Ingredient	Ounces (volume)		3	0.066	Active Ingredient	Ounces (volume)		7	0.48	Product	Ounces (volume)	
Creeks	15	52.51	Active Ingredient	Ounces (volume)		12	5.04	Active Ingredient	Ounces (volume)		1	0.09	Product	Ounces (volume)	
Ditches															
Intermittent	11	360.1	Active Ingredient	Ounces (volume)		9	37.13	Active Ingredient	Ounces (volume)						
Marshes	7	158.03	Active Ingredient	Ounces (volume)		7	16.38	Active Ingredient	Ounces (volume)						
Natural Ponds	31	64.68	Active Ingredient	Ounces (volume)		22	4.38	Active Ingredient	Ounces (volume)		2	0.12	Product	Ounces (volume)	
Ornamental Ponds															
Park/Landscape															
Rainwater															
Sanitary															
Seepages															
Swimming Pools	31	3.44	Active Ingredient	Ounces (volume)		25	0.25	Active Ingredient	Ounces (volume)		7	0.72	Product	Ounces (volume)	
Tires															
TreeHoles											1	0.03	Product	Ounces (volume)	
Urban Underground Water															
Waterfront															
Wells															
Totals	98	639.39	Active Ingredient	Ounces (volume)		78	63.246	Active Ingredient	Ounces (volume)		18	1.44	Product	Ounces (volume)	

Table A13.

Application Sites:	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit18	BVA-2 Comments	VectoLex CG - # Treatments	Total Amount Used19	Total Amount Type20	Total Amount Unit20	VectoLex CG Comments	VectoMax WSP - # Treatments	Total Amount Used21	Total Amount Type22	Total Amount Unit22	VectoMax WSP Comments
Canals															
Containers	2	15.5	Product	Ounces (volume)		1	0.18	Product	Ounces (volume)						
Creeks	1	4	Product	Ounces (volume)											
Ditches															
Intermittent															
Marshes	1	12	Product	Ounces (volume)		1	48	Product	Ounces (volume)		3	608	Product	Ounces (volume)	
Natural Ponds	1	15	Product	Ounces (volume)		4	208	Product	Ounces (volume)		1	80	Product	Ounces (volume)	
Ornamental Ponds															
Park/Landscape															
Rainwater															
Sanitary															
Seepages															
Swimming Pools	3	6	Product	Ounces (volume)		4	2.35	Product	Ounces (volume)		2	0.85	Product	Ounces (volume)	
Tires															
TreeHoles															
Urban Underground Water															
Waterfront															
Wells															
Totals	8	52.5	Product	Ounces (volume)		10	258.53	Product	Ounces (volume)		6	688.85	Product	Ounces (volume)	

Table A13.

Application Sites:	Altosid WSP (pellets) - # Treatments	Total Amount Used23	Total Amount Type24	Total Amount Unit24	Altosid WSP (pellets) Commnets	Bell Contrac Super-Size Blox - # Treatments	Total Amount Used35	Total Amount Type36	Total Amount Unit36	Bell Contrac Super-Size Blox Comments	Altosid XR-Briquets - # Treatments	Total Amount Used37	Total Amount Type38
Canals													
Containers	3	2.64	Product	Ounces (volume)							4	61.5	Product
Creeks	1	1.68	Product	Ounces (volume)		24	208	Product	Ounces (volume)		2	6	Product
Ditches													
Intermittent													
Marshes	1	1.68	Product	Ounces (volume)									
Natural Ponds	7	8.88	Product	Ounces (volume)							1	1.5	Product
Ornamental Ponds													
Park/Landscape						8	64	Product	Ounces (volume)				
Rainwater													
Sanitary						22	336	Product	Ounces (volume)				
Seepages													
Swimming Pools	2	1.92	Product	Ounces (volume)							24	46.5	Product
Tires													
TreeHoles													
Urban Underground Water											2	15	Product
Waterfront						8	64	Product	Ounces (volume)				
Wells													
Totals	14	16.8	Product	Ounces (volume)		62	672	Product	Ounces (volume)		33	130.5	Product

Table A13.

Application Sites:	Total Amount Unit38	Altosid XR-Briquets Comments	Bell Contrac Small Blox - # Treatments	Total Amount Used69	Total Amount Type710	Total Amount Unit711	Bell Contrac Small Blox Comments	Drione - # Treatments	Total Amount Used1112	Total Amount Type1213	Total Amount Unit1214	Drione Comments	Bell Terad 3 Blox - # Treatments	Total Amount Used1315
Canals														
Containers	Ounces (volume)													
Creeks	Ounces (volume)		5	5	Product	Ounces (volume)							3	3
Ditches														
Intermittent														
Marshes														
Natural Ponds	Ounces (volume)													
Ornamental Ponds														
Park/Landscape			2	2	Product	Ounces (volume)		1	1.5	Product	Ounces (volume)		5	12
Rainwater														
Sanitary														
Seepages														
Swimming Pools	Ounces (volume)													
Tires														
TreeHoles														
Urban Underground Water	Ounces (volume)													
Waterfront														
Wells														
Totals	Ounces (volume)		7	7	Product	Ounces (volume)		1	1.5	Product	Ounces (volume)		8	15

Table A13.

Application Sites:	Total Amount Type1416	Total Amount Unit1417	Bell Terad 3 Blox Comments	First Strike - # Treatments	Total Amount Used1518	Total Amount Type1619	Total Amount Unit1620	First Strike Comments	VectoLex CG Biologic - # Treatments	Total Amount Used3142	Total Amount Type3243	Total Amount Unit3244	VectoLex CG Biologic Comments	VectoLex WDG - # Treatments
Canals														
Containers									1	0.18	Product	Ounces (volume)		
Creeks	Product	Ounces (volume)		2	1.41	Product	Ounces (volume)							6
Ditches														
Intermittent														6
Marshes									1	48	Product	Ounces (volume)		
Natural Ponds									4	208	Product	Ounces (volume)		
Ornamental Ponds														
Park/Landscape	Product	Ounces (volume)		2	3.88	Product	Ounces (volume)							
Rainwater														
Sanitary														
Seepages														
Swimming Pools									4	2.35	Product	Ounces (volume)		
Tires														
TreeHoles														
Urban Underground Water														
Waterfront														
Wells														
Totals	Product	Ounces (volume)		4	5.29	Product	Ounces (volume)		10	258.53	Product	Ounces (volume)		12

Table A13.

Application Sites:	Total Amount Used3345	Total Amount Type3446	Total Amount Unit3447	VectoLex WDG Comments	Ditrac Blox - # Treatments	Total Amount Used3	Total Amount Type	Total Amount Unit4	Ditrac Blox Comments	Vectolex WSP - # Treatments	Total Amount Used5	Total Amount Type6	Total Amount Unit8	Vectolex WSP Comments	Altosid Pellets - # Treatments
Canals															
Containers										1	3.04	Product	Ounces (volume)		2
Creeks	96	Active Ingredient	Ounces (volume)		8	128	Product	Ounces (volume)							3
Ditches															
Intermittent	672	Active Ingredient	Ounces (volume)												1
Marshes										1	5.32	Product	Ounces (volume)		4
Natural Ponds															12
Ornamental Ponds															
Park/Landscape					1	16	Product	Ounces (volume)							
Rainwater															
Sanitary															
Seepages															
Swimming Pools										6	25.84	Product	Ounces (volume)		
Tires															
TreeHoles															
Urban Underground Water										1	0.76	Product	Ounces (volume)		
Waterfront															
Wells															
Totals	768	Active Ingredient	Ounces (volume)		9	144	Product	Ounces (volume)		9	34.96	Product	Ounces (volume)		22

Table A13.

Application Sites:	Total Amount Used	Total Amount Type9	Total Amount Unit	Altosid Pellets - Comments
Canals				
Containers	32	Product	Ounces (volume)	
Creeks	36	Product	Ounces (volume)	
Ditches				
Intermittent	8	Product	Ounces (volume)	
Marshes	100	Product	Ounces (volume)	
Natural Ponds	424	Product	Ounces (volume)	
Ornamental Ponds				
Park/Landscape				
Rainwater				
Sanitary				
Seepages				
Swimming Pools				
Tires				
TreeHoles				
Urban Underground Water				
Waterfront				
Wells				
Totals	600	Product	Ounces (volume)	

Table A14. **Pesticide Application Data for Spring 2012 – CCMVCD**

Application Sites:	Agnique MMF - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Agnique MMF Comments	VectoBac G - # Treatments	Total Amount Used2	Total Amount Type3	Total Amount Unit3	VectoBac G Comments	VectoBac 12AS - # Treatments	Total Amount Used6	Total Amount Type7	Total Amount Unit7	VectoBac 12AS Comments
Canals															
Containers	6	27.41	Product	Ounces (volume)		3	34.29	Product	Ounces (volume)		13	4.03	Active Ingredient	Ounces (volume)	
Creeks	1	2.56	Product	Ounces (volume)		14	894.87	Product	Ounces (volume)		183	214.85	Active Ingredient	Ounces (volume)	
Ditches															
Intermittent						1	128	Product	Ounces (volume)		21	406.4	Active Ingredient	Ounces (volume)	
Marshes						3	264	Product	Ounces (volume)		26	853.77	Active Ingredient	Ounces (volume)	
Natural Ponds	2	0.51	Product	Ounces (volume)		11	496	Product	Ounces (volume)		83	344.37	Active Ingredient	Ounces (volume)	
Ornamental Ponds															
Other															
Park/Landscape															
Rainwater															
Sanitary	1	1.5	Product	Ounces (volume)											
Seepages															
Swimming Pools	21	11.26	Product	Ounces (volume)		2	3.59	Product	Ounces (volume)		66	7.85	Active Ingredient	Ounces (volume)	
Tires															
TreeHoles															
Urban Underground Water											3	0.44	Active Ingredient	Ounces (volume)	
Waterfront															
Wells															
Totals	31	43.24	Product	Ounces (volume)		34	1820.75	Product	Ounces (volume)		395	1831.71	Active Ingredient	Ounces (volume)	

Table A14.

Application Sites:	Altosid Liquid conc. - # Treatments	Total Amount Used11	Total Amount Type12	Total Amount Unit12	Altosid Liquid conc. Comments	Altosid Briquets - # Treatments	Total Amount Used13	Total Amount Type14	Total Amount Unit14	Altosid Briquets Comments	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit18
Canals														
Containers	3	0.13	Active Ingredient	Ounces (volume)		21	2.7	Product	Ounces (volume)		21	66	Product	Ounces (volume)
Creeks	16	15.5	Active Ingredient	Ounces (volume)							16	123	Product	Ounces (volume)
Ditches														
Intermittent	11	41.32	Active Ingredient	Ounces (volume)		1	0.3	Product	Ounces (volume)		22	20744	Product	Ounces (volume)
Marshes	18	85.57	Active Ingredient	Ounces (volume)							3	52	Product	Ounces (volume)
Natural Ponds	50	33.94	Active Ingredient	Ounces (volume)		3	0.12	Product	Ounces (volume)		15	2713.5	Product	Ounces (volume)
Ornamental Ponds														
Other														
Park/Landscape											2	2	Product	Ounces (volume)
Rainwater														
Sanitary														
Seepages														
Swimming Pools	29	0.23	Active Ingredient	Ounces (volume)		10	1.83	Product	Ounces (volume)		31	53	Product	Ounces (volume)
Tires														
TreeHoles														
Urban Underground Water						19	4.77	Product	Ounces (volume)		110	1639.25	Product	Ounces (volume)
Waterfront														
Wells														
Totals	127	176.69	Active Ingredient	Ounces (volume)		54	9.72	Product	Ounces (volume)		220	25392.75	Product	Ounces (volume)

Table A14.

Application Sites:	BVA-2 Comments	VectoLex CG - # Treatments	Total Amount Used19	Total Amount Type20	Total Amount Unit20	VectoLex CG Comments	VectoMax WSP - # Treatments	Total Amount Used21	Total Amount Type22	Total Amount Unit22	VectoMax WSP Comments	Altosid WSP (pellets) - # Treatments	Total Amount Used23	Total Amount Type24
Canals														
Containers		12	304.76	Product	Ounces (volume)							7	9.36	Product
Creeks		56	2001.27	Product	Ounces (volume)		1	16	Product	Ounces (volume)		7	3.36	Product
Ditches														
Intermittent		5	160.18	Product	Ounces (volume)									
Marshes		5	368	Product	Ounces (volume)							1	1.68	Product
Natural Ponds		58	4325.69	Product	Ounces (volume)		2	162	Product	Ounces (volume)		2	1.44	Product
Ornamental Ponds														
Other		1	0.36	Product	Ounces (volume)									
Park/Landscape														
Rainwater														
Sanitary		1	1	Product	Ounces (volume)									
Seepages														
Swimming Pools		27	20.23	Product	Ounces (volume)							1	0.96	Product
Tires														
TreeHoles														
Urban Underground Water		1	40	Product	Ounces (volume)							5	1.92	Product
Waterfront														
Wells														
Totals		166	7221.49	Product	Ounces (volume)		3	178	Product	Ounces (volume)		23	18.72	Product

Table A14.

Application Sites:	Total Amount Unit24	Altosid WSP (pellets) Commnets	MetaLarv SP-T - # Treatments	Total Amount Used25	Total Amount Type26	Total Amount Unit26	MetaLarv SP-T Comments	FourStar SR Briquet - # Treatments	Total Amount Used27	Total Amount Type28	Total Amount Unit28	FourStar SR Briquet Comments	Bell Contrac Super-Size Blox - # Treatments
Canals													
Containers	Ounces (volume)							6	8.8	Product	Ounces (volume)		
Creeks	Ounces (volume)												21
Ditches													
Intermittent			2	3072	Product	Ounces (volume)							
Marshes	Ounces (volume)												
Natural Ponds	Ounces (volume)							1	1.1	Product	Ounces (volume)		1
Ornamental Ponds													
Other													
Park/Landscape													20
Rainwater													
Sanitary													40
Seepages													
Swimming Pools	Ounces (volume)							11	22	Product	Ounces (volume)		
Tires													
TreeHoles													
Urban Underground Water	Ounces (volume)							179	3388	Product	Ounces (volume)		
Waterfront													20
Wells													
Totals	Ounces (volume)		2	3072	Product	Ounces (volume)		197	3419.9	Product	Ounces (volume)		102

Table A14.

Application Sites:	Total Amount Used35	Total Amount Type36	Total Amount Unit36	Bell Contrac Super-Size Blox Comments	Altosid XR-Briquets - # Treatments	Total Amount Used37	Total Amount Type38	Total Amount Unit38	Altosid XR-Briquets Comments	Bell Contrac Small Blox - # Treatments	Total Amount Used69	Total Amount Type710	Total Amount Unit711
Canals													
Containers					35	244.5	Product	Ounces (volume)					
Creeks	184	Product	Ounces (volume)		16	88.5	Product	Ounces (volume)		4	10	Product	Ounces (volume)
Ditches													
Intermittent					2	31.5	Product	Ounces (volume)					
Marshes					4	24	Product	Ounces (volume)					
Natural Ponds	24	Product	Ounces (volume)		14	42	Product	Ounces (volume)		2	21	Product	Ounces (volume)
Ornamental Ponds													
Other										1	1	Product	Ounces (volume)
Park/Landscape	160	Product	Ounces (volume)							1	3	Product	Ounces (volume)
Rainwater													
Sanitary	472	Product	Ounces (volume)										
Seepages													
Swimming Pools					27	58.5	Product	Ounces (volume)					
Tires													
TreeHoles													
Urban Underground Water					177	4824	Product	Ounces (volume)					
Waterfront	160	Product	Ounces (volume)							1	8	Product	Ounces (volume)
Wells													
Totals	1000	Product	Ounces (volume)		275	5313	Product	Ounces (volume)		9	43	Product	Ounces (volume)

Table A14.

Application Sites:	Bell Contrac Small Blox Comments	Drione - # Treatments	Total Amount Used1112	Total Amount Type1213	Total Amount Unit1214	Drione Comments	Bell Terad 3 Blox - # Treatments	Total Amount Used1315	Total Amount Type1416	Total Amount Unit1417	Bell Terad 3 Blox Comments	First Strike - # Treatments	Total Amount Used1518	Total Amount Type1619
Canals														
Containers		1	0.5	Product	Ounces (volume)									
Creeks							3	7	Product	Ounces (volume)		2	2.12	Product
Ditches														
Intermittent														
Marshes														
Natural Ponds														
Ornamental Ponds														
Other														
Park/Landscape		46	26.55	Product	Ounces (volume)							2	4.94	Product
Rainwater														
Sanitary														
Seepages														
Swimming Pools														
Tires														
TreeHoles														
Urban Underground Water														
Waterfront														
Wells														
Totals		47	27.05	Product	Ounces (volume)		3	7	Product	Ounces (volume)		4	7.06	Product

Table A14.

Application Sites:	Total Amount Unit1620	First Strike Comments	Pyrocide 7396 - # Treatments	Total Amount Used2939	Total Amount Type3040	Total Amount Unit3041	Pyrocide 7396 Comments	VectoLex CG Biologic - # Treatments	Total Amount Used3142	Total Amount Type3243	Total Amount Unit3244	VectoLex CG Biologic Comments	VectoLex WDG - # Treatments
Canals													
Containers								12	304.76	Product	Ounces (volume)		
Creeks	Ounces (volume)							56	2001.27	Product	Ounces (volume)		
Ditches													
Intermittent			12	193.39	Product	Ounces (volume)		5	160.18	Product	Ounces (volume)		13
Marshes								5	368	Product	Ounces (volume)		
Natural Ponds								58	4325.69	Product	Ounces (volume)		2
Ornamental Ponds													
Other								1	0.36	Product	Ounces (volume)		
Park/Landscape	Ounces (volume)		2	15.75	Product	Ounces (volume)							
Rainwater													
Sanitary								1	1	Product	Ounces (volume)		
Seepages													
Swimming Pools								27	20.23	Product	Ounces (volume)		
Tires													
TreeHoles													
Urban Underground Water								1	40	Product	Ounces (volume)		3
Waterfront													
Wells													
Totals	Ounces (volume)		14	209.14	Product	Ounces (volume)		166	7221.49	Product	Ounces (volume)		18

Table A14.

Application Sites:	Total Amount Used3345	Total Amount Type3446	Total Amount Unit3447	VectoLex WDG Comments	Ditrac Blox - # Treatments	Total Amount Used3	Total Amount Type	Total Amount Unit4	Ditrac Blox Comments	Vectolex WSP - # Treatments	Total Amount Used5	Total Amount Type6	Total Amount Unit8	Vectolex WSP Comments	Altosid Pellets - # Treatments
Canals															
Containers										5	15.2	Product	Ounces (volume)		3
Creeks					14	224	Product	Ounces (volume)		4	8.36	Product	Ounces (volume)		32
Ditches															
Intermittent	1168	Active Ingredient	Ounces (volume)												52
Marshes															28
Natural Ponds	24	Active Ingredient	Ounces (volume)												22
Ornamental Ponds															
Other															
Park/Landscape					4	64	Product	Ounces (volume)							
Rainwater															
Sanitary															1
Seepages															
Swimming Pools										3	13.68	Product	Ounces (volume)		
Tires															
TreeHoles															
Urban Underground Water	3.31	Product	Ounces (volume)							1	1.52	Product	Ounces (volume)		1
Waterfront															
Wells															
Totals	1195.31	Product	Ounces (volume)		18	288	Product	Ounces (volume)		13	38.76	Product	Ounces (volume)		139

Table A14.

Application Sites:	Total Amount Used	Total Amount Type9	Total Amount Unit	Altosid Pellets - Comments
Canals				
Containers	17.15	Product	Ounces (volume)	
Creeks	766	Product	Ounces (volume)	
Ditches				
Intermittent	10209.5	Product	Ounces (volume)	
Marshes	1144	Product	Ounces (volume)	
Natural Ponds	531	Product	Ounces (volume)	
Ornamental Ponds				
Other				
Park/Landscape				
Rainwater				
Sanitary	10	Product	Ounces (volume)	
Seepages				
Swimming Pools				
Tires				
TreeHoles				
Urban Underground Water	1	Product	Ounces (volume)	
Waterfront				
Wells				
Totals	12678.65	Product	Ounces (volume)	

Table A15. Pesticide Product Key CCMVCD

Product	AI	Vector
Agnique MMF	Biodegradable Alcohol Ethoxylated Surfactant	Mosquito
Agnique MMF G	Biodegradable Alcohol Ethoxylated Surfactant	Mosquito
Altosid Briquets	Methoprene	Mosquito
Altosid Liquid conc.	Methoprene	Mosquito
Altosid Pellets	Methoprene	Mosquito
Altosid WSP (pellets)	Methoprene	Mosquito
Altosid XR-Briquets	Methoprene	Mosquito
Bell Contrac Small Blox	Bromadiolone	Rat
Bell Contrac Super-Size Blox	Bromadiolone	Rat
Bell Terad 3 Blox	Cholecalciferol	Rat
BVA 2	Petroleum Distillate	Mosquito
Drione	Pyrethrin and Piperonyl Butroxide and Amorphous Silica Gel	Yellow Jacket / Wasp
First Strike	Difethialone	Rat
FourStar SR Briquet 180-90-45	Bacillus Sphaericus and Bacillus Thuringiensis Israelensis	Mosquito
MetaLarv SP-T	Methoprene	Mosquito
Natular 2EC	Spinosad	Mosquito
Pyrocide 7396	Pyrethrins and Piperonyl Butoxide	Mosquito
VectoBac 12AS	Bacillus Thuringiensis Israelensis	Mosquito
VectoBac G	Bacillus Thuringiensis Israelensis	Mosquito
VectoLex CG Biologic	Bacillus Sphaericus	Mosquito
VectoLex WDG	Bacillus Sphaericus	Mosquito
VectoLex WSP	Bacillus Sphaericus	Mosquito
VectoMax WSP	Bacillus Sphaericus and Bacillus Thuringiensis Israelensis	Mosquito
Ditrac Blox	Difethialone	Rat

Table A16. **Pesticide Application Data for Summer 2011 – MSMVCD**

Application Sites:	Agnique MMF - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Agnique MMF Comments	Agnique MMF G - # Treatments	Total Amount Used4	Total Amount Type5	Total Amount Unit5	Agnique MMF G Comments	VectoBac 12AS - # Treatments	Total Amount Used6	Total Amount Type7	Total Amount Unit7	VectoBac 12AS Comments	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit18	BVA-2 Comments	VectoBac Technical Powder - # Treatments	Total Amount Used19	Total Amount Type20	Total Amount Unit20	VectoBac Technical Powder Comments	Delta Dust - # Treatments	Total Amount Used31	Total Amount Type32	Total Amount Unit32
Anthropogenic Sources	120	0.736	Product	Gallons												71	4.506	Product	Gallons		1	0.0035	Product	Pounds		1	0.063	Product	Pounds
Drainage Ditch Man Made	8	0.024	Product	Gallons												4	2.127	Product	Gallons		1	0.0017	Product	Pounds					
Manmade Wetlands	1	0.01	Product	Gallons																									
Manmade Wetlands Seasonal	1	0.012	Product	Gallons							4	32.754	Product	Gallons															
Wetland Permanent Treated Effluent																													
Natural Wetlands																													
Natural Wetlands Seasonal											2	16.5	Product	Gallons															
Vernal Pool																													
Vernal Pool Manmade																													
Mitigated Wetlands Seasonal																													
Wildlife Refuge																													
Pond	60	0.144	Product	Gallons							5	1.315	Product	Gallons		19	3.101	Product	Gallons		5	0.253	Product	Pounds					
Wildlife Pond																													
Rain Pond	3	0.153	Product	Gallons																									
Natural Spring	3	0.006	Product	Gallons												1	0.025	Product	Gallons										
Low Area	10	0.217	Product	Gallons							14	2.72	Product	Gallons		3	0.034	Product	Gallons		1	0.002	Product	Pounds					
Waterways																													
Creeks	11	0.048	Product	Gallons							7	0.493	Product	Gallons		1	0.0012	Product	Gallons		10	0.106	Product	Pounds					
Treehole																													
Culvert	1	0.001	Product	Gallons																	1	0.005	Product	Pounds					
Natural Ditch	2	0.112	Product	Gallons							3	98.512	Product	Gallons		5	0.897	Product	Gallons							1	0.063	Product	Pounds
Flood Control Ditch											1	0.008	Product	Gallons		1	0.001	Product	Gallons										
Marshes (Fresh Water)											1	0.75	Product	Gallons															
Marsh - Seasonal											5	27.284	Product	Gallons		1	1	Product	Gallons										
Marsh - Tidal	2	0.024	Product	Gallons							8	190.943	Product	Gallons		2	0.075	Product	Gallons		1	0.006	Product	Pounds					
Residential Areas																													
Industrial Areas																													
Recreational Areas																													
Agricultural Areas																													
Aeration Pond																3	0.9	Product	Gallons										
Waste Pond	19	1.074	Product	Gallons							2	1	Product	Gallons		36	219.271	Product	Gallons										
Reservoir											1	0.125	Product	Gallons															
Settling Pond	6	0.03	Product	Gallons												1	1	Product	Gallons										
Hayfield Ditch											3	3	Product	Gallons															
Pastures																													
Irrigated Reservoir	1	0.014	Product	Gallons																									
Swamps																													
Overgrown Waste Areas																													
Roadsides																													
Roadside Ditch	16	0.086	Product	Gallons												12	4.42	Product	Gallons		3	0.003	Product	Pounds					
Woodlands																													
Gardens																													
Playgrounds																													
Campsites																													
Athletic Fields																													
Municipalities																													
Catch Basin	14	0.033	Product	Gallons												117	5.86	Product	Gallons		5	0.006	Product	Pounds					
Waste Treatment Plant	7	0.419	Product	Gallons		4	1980	Product	Pounds		1	3.626	Product	Gallons		12	0.769	Product	Gallons										
Water Treatment Plant	2	0.017	Product	Gallons												23	61.16	Product	Gallons										
Wildlife Refuge Treated Effluent											6	7.751	Product	Gallons															
Overland Flow																													
Waste Water Irrigation (e.g. pastures)																2	1.422	Product	Gallons										
Storm Sewer Line																													
Storm Water BMP																													
Retention Basin	1	0.002	Product	Gallons																	1	0.006	Product	Pounds					
Sewer Pond	2	0.545	Product	Gallons							6	2.373	Product	Gallons		9	6.961	Product	Gallons										
Indoors																													
Total	290	3.707	Product	Gallons		4	1980	Product	Pounds		69	389.154	Product	Gallons		323	313.5302	Product	Gallons		29	0.3922	Product	Pounds		2	0.126	Product	Pounds

Table A16.

Application Sites:	Delta Dust Comments	Wasp Freeze - # Treatments	Total Amount Used33	Total Amount Type34	Total Amount Unit34	Wasp Freeze Comments	Drione - # Treatments	Total Amount Used1112	Total Amount Type1213	Total Amount Unit1214	Drione Comments	FourStar 45 - # Treatments	Total Amount Used2127	Total Amount Type2228	Total Amount Unit2229	FourStar 45 Comments	VectoLex WDG - # Treatments	Total Amount Used3345	Total Amount Type3446	Total Amount Unit3447	VectoLex WDG Comments	Zenivex - # Treatments	Total Amount Used3548	Total Amount Type3649	Total Amount Unit3650	Zenivex Comments	Pyrocide Tegging concentrate 7396 - # Treatments	Total Amount Used3144	Total Amount Type3245
Anthropogenic Sources		1	0.016	Product	Gallons		14	1.377	Product	Pounds							3	0.037	Product	Pounds							17	0.325	Product
Drainage Ditch Man Made																	5	1.199	Product	Pounds									
Manmade Wetlands																													
Manmade Wetlands Seasonal																	5	4.3	Product	Pounds									
Wetland Permanent Treated Effluent																													
Natural Wetlands																													
Natural Wetlands Seasonal																	1	1	Product	Pounds									
Vernal Pool																													
Vernal Pool Manmade																													
Mitigated Wetlands Seasonal																													
Wildlife Refuge																													
Pond							11	1.25	Product	Pounds		1	0.21	Active Ingredient	Pounds		6	6.45	Product	Pounds							5	0.304	Product
Wildlife Pond																													
Rain Pond																													
Natural Spring																													
Low Area																	7	10.753	Product	Pounds									
Waterways																													
Creeks							1	0.063	Product	Pounds							1	0.2	Product	Pounds							5	0.313	Product
Treehole																											1	2.078	Product
Culvert																													
Natural Ditch							2	0.438	Product	Pounds							6	9.8	Product	Pounds									
Flood Control Ditch																													
Marshes (Fresh Water)																	1	3	Product	Pounds									
Marsh - Seasonal																	1	5	Product	Pounds									
Marsh - Tidal																													
Residential Areas																													
Industrial Areas																													
Recreational Areas																													
Agricultural Areas																													
Aeration Pond																													
Waste Pond																	9	3.938	Product	Pounds									
Reservoir																	1	0.5	Product	Pounds									
Settling Pond																													
Hayfield Ditch																	15	30.127	Product	Pounds									
Pastures																													
Irrigated Reservoir							3	1	Product	Pounds																			
Swamps																													
Overgrown Waste Areas																													
Roadsides																													
Roadside Ditch																	1	0.2	Product	Pounds									
Woodlands																													
Gardens																													
Playgrounds																													
Campsites																													
Athletic Fields																													
Municipalities																													
Catch Basin							1	0.063	Product	Pounds							1	0.007	Product	Pounds								0.004	Product
Waste Treatment Plant							1	0.063	Product	Pounds							2	0.01	Product	Pounds		1	0.266	Product	Gallons		7	0.035	Product
Water Treatment Plant																													
Wildlife Refuge Treated Effluent																	6	31	Product	Pounds									
Overland Flow																													
Waste Water Irrigation (e.g. pastures)																	8	2.75	Product	Pounds									
Storm Sewer Line																													
Storm Water BMP																													
Retention Basin																													
Sewer Pond																	5	8.6	Product	Pounds									
Indoors																													
Total		1	0.016	Product	Gallons		33	4.254	Product	Pounds		1	0.21	Active Ingredient	Pounds		84	118.871	Product	Pounds		1	0.266	Product	Gallons		35	3.059	Product

Table A16.

Application Sites:	Total Amount Unit3246	Pyrocide fogging concentrate 7396 Comments	VectoBac GS - # Treatments	Total Amount Used3347	Total Amount Type3448	Total Amount Unit3449	VectoBac GS Comments	Altosid Liquid Concentrate - # Treatments	Total Amount Used6966	Total Amount Type71067	Total Amount Unit71168	Altosid Liquid Concentrate Comments	Altosid Pellets - # Treatments	Total Amount Used111269	Total Amount Type121370	Total Amount Unit121471	Altosid Pellets Comments	Altosid SBG - # Treatments	Total Amount Used131572	Total Amount Type141673	Total Amount Unit141774	Altosid SBG Comments	Altosid XR Briquets - # Treatments	Total Amount Used151875	Total Amount Type161976	Total Amount Unit162077	Altosid XR Briquets Comments	Altosid Briquettes (Standard) -# Treatments
Anthropogenic Sources	Gallons												95	32.217	Product	Pounds								332	111.218	Product	Pounds	each	25
Drainage Ditch Man Made													4	0.159	Product	Pounds								4	1	Product	Pounds	each	2
Manmade Wetlands																												
Manmade Wetlands Seasonal																												
Wetland Permanent Treated Effluent																												
Natural Wetlands																												
Natural Wetlands Seasonal																												
Vernal Pool																												
Vernal Pool Manmade																												
Mitigated Wetlands Seasonal																												
Wildlife Refuge																												
Pond	Gallons		1	0.034	Product	Pounds							13	1.958	Product	Pounds								199	35.333	Active Ingredient	Pounds	each	6
Wildlife Pond													1	0.01	Product	Pounds												
Rain Pond			1	2.25	Product	Pounds							1	0.028	Product	Pounds								1	0.444	Product	Pounds	each	
Natural Spring													1	0.2	Product	Pounds								2	0.889	Product	Pounds	each	
Low Area													12	3.669	Product	Pounds								3	0.667	Product	Pounds	each	1
Waterways																												
Creeks	Gallons												44	7.877	Product	Pounds								6	1.222	Product	Pounds	each	3
Treehole	Gallons																							1	0.111	Product	Pounds	each	
Culvert													1	0.007	Product	Pounds								1	0.111	Product	Pounds	each	
Natural Ditch													7	0.948	Product	Pounds								4	1.222	Product	Pounds	each	
Flood Control Ditch													3	0.062	Product	Pounds												
Marshes (Fresh Water)																												
Marsh - Seasonal								3	1.692	Product	Gallons		5	108.14	Product	Pounds												
Marsh - Tidal			3	10.011	Product	Pounds		4	12.713	Product	Gallons		31	223.782	Product	Pounds												
Residential Areas																												
Industrial Areas																												
Recreational Areas																												
Agricultural Areas																												
Aeration Pond																												
Waste Pond			2	1.092	Product	Pounds							1	4.5	Product	Pounds												
Reservoir													1	0.01	Product	Pounds												
Settling Pond																								1	0.222	Product	Pounds	each	
Hayfield Ditch													1	1	Product	Pounds												
Pastures																												
Irrigated Reservoir																												
Swamps																												
Overgrown Waste Areas																												
Roadsides																												
Roadside Ditch			1	0.625	Product	Pounds																		1	0.111	Product	Pounds	each	6
Woodlands																												
Gardens																												
Playgrounds																												
Campsites																												
Athletic Fields																												
Municipalities																												
Catch Basin	Gallons												7	0.012	Product	Pounds								327	7,104.37	Product	Pounds	each	19
Waste Treatment Plant	Gallons							1	0.242	Product	Gallons		3	1.12	Product	Pounds								3	0.444	Product	Pounds	each	
Water Treatment Plant																								2	2.111	Product	Pounds	each	
Wildlife Refuge Treated Effluent																												
Overland Flow																												
Waste Water Irrigation (e.g. pastures)													1	0.009	Product	Pounds								2	1.333	Product	Pounds	each	
Storm Sewer Line																												
Storm Water BMP																												
Retention Basin													1	0.003	Product	Pounds		1	0.48	Product	Pounds							
Sewer Pond													3	0.758	Product	Pounds												
Indoors																												
Total	Gallons		8	14.012	Product	Pounds		8	14.647	Product	Gallons		236	386.469	Product	Pounds		1	0.48	Product	Pounds		889	7260.812	Product	Pounds	each	62

Table A16.

Application Sites:	Total Amount Used	Total Amount Type2	Total Amount Unit	Altosid Briquettes Comments	Vectolex CG - # Treatments	Total Amount Used3	Total Amount Type4	Total Amount Unit5	Vectolex CG Comments	Vectomax CG - # Treatments	Total Amount Used6	Total Amount Type7	Total Amount Unit8	Vectomax CG Comments	VectoLex WSP - # Treatments	Total Amount Used5	Total Amount Type6	Total Amount Unit7	VectoLex WSP Comments	Altosid Liquid (non-concentrate) - # Treatments	Total Amount Used8	Total Amount Type9	Total Amount Unit10	Altosid Liquid (non-concentrate) comments
Anthropogenic Sources	1.63	Product	Pounds	each	28	6.767	Product	Pounds		18	3.934	Product	Pounds		23	0.858	Product	Pounds	each					
Drainage Ditch Man Made	0.029	Product	Pounds	each	8	53.919	Product	Pounds		6	13.057	Product	Pounds		1	0.088	Product	Pounds	each					
Manmade Wetlands																								
Manmade Wetlands Seasonal					2	38	Product	Pounds												4	4.09	Product	Gallons	
Wetland Permanent Treated Effluent										5	45	Product	Pounds											
Natural Wetlands																				1	0.062	Product	Gallons	
Natural Wetlands Seasonal										1	1200	Product	Pounds											
Vernal Pool																								
Vernal Pool Manmade																								
Mitigated Wetlands Seasonal																								
Wildlife Refuge																								
Pond	0.186	Product	Pounds	each	16	63.027	Product	Pounds		14	82.525	Product	Pounds		12	0.308	Product	Pounds	each					
Wildlife Pond										1	160	Product	Pounds											
Rain Pond					3	10.1	Product	Pounds		7	95.114	Product	Pounds											
Natural Spring					1	0.45	Product	Pounds		2	0.206	Product	Pounds											
Low Area	0.014	Product	Pounds	each	5	108.05	Product	Pounds		8	20.524	Product	Pounds		1	0.022	Product	Pounds	each					
Waterways																								
Creeks	0.186	Product	Pounds	each						2	13	Product	Pounds											
Treehole																								
Culvert					2	0.041	Product	Pounds																
Natural Ditch					9	57.96	Product	Pounds		1	0.5	Product	Pounds							1	11.988	Product	Gallons	
Flood Control Ditch					5	20.771	Product	Grams		1	2	Product	Pounds											
Marshes (Fresh Water)					2	1.2	Product	Pounds																
Marsh - Seasonal					1	20	Product	Pounds																
Marsh - Tidal					2	0.207	Product	Pounds		7	17.092	Product	Pounds											
Residential Areas																								
Industrial Areas																								
Recreational Areas																								
Agricultural Areas																								
Aeration Pond										4	12.404	Product	Pounds											
Waste Pond					14	185.15	Product	Pounds		36	142.387		Pounds		2	0.198	Product	Pounds	each					
Reservoir					1	60	Product	Pounds																
Settling Pond																								
Hayfield Ditch					8	115.97	Product	Pounds												1	0.187	Product	Gallons	
Pastures																								
Irrigated Reservoir					2	20	Product	Pounds																
Swamps																								
Overgrown Waste Areas																								
Roadsides																								
Roadside Ditch	0.143	Product	Pounds	each	1	0.037	Product	Pounds		10	3.151	Product	Pounds		2	0.066	Product	Pounds	each					
Woodlands																								
Gardens																								
Playgrounds																								
Campsites																								
Athletic Fields																								
Municipalities																								
Catch Basin	0.557	Product	Pounds	each	3	0.018	Product	Pounds		3	0.011	Product	Pounds		109	6.622	Product	Pounds	each					
Waste Treatment Plant					3	0.638	Product	Pounds		3	2360	Product	Pounds		8	0.418	Product	Pounds	each					
Water Treatment Plant															1	0.022	Product	Pounds	each					
Wildlife Refuge Treated Effluent					4	600	Product	Pounds												5	0.656	Product	Gallons	
Overland Flow																								
Waste Water Irrigation (e.g. pastures)					70	1748.723	Product	Pounds		20	211.4	Product	Pounds		3	0.176	Active Ingredient	Pounds	each					
Storm Sewer Line																								
Storm Water BMP																								
Retention Basin					3	11.3	Product	Pounds		1	0.8	Product	Pounds											
Sewer Pond					5	32	Product	Pounds		11	382.1	Product	Pounds											
Indoors																								
Total	2.745	Product	Pounds	each	198	3154.328	Product	Pounds		161	4765.205	Product	Pounds		162	8.778	Mix	Pounds	each	12	16.983	Product	Gallons	

Table A17. **Pesticide Application Data for Fall 2011 – MSMVCD**

Application Sites:	Agnique MMF - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Agnique MMF Comments	VectoBac 12AS - # Treatments	Total Amount Used6	Total Amount Type7	Total Amount Unit7	VectoBac 12AS Comments	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit18	BVA-2 Comments	VectoBac Technical Powder - # Treatments	Total Amount Used19	Total Amount Type20	Total Amount Unit20	VectoBac Technical Powder Comments	Drione - # Treatments	Total Amount Used1112	Total Amount Type1213	Total Amount Unit1214	Drione Comments	VectoLex WDG - # Treatments
Anthropogenic Sources	72	0.738	Product	Gallons							24	3.448	Product	Gallons		2	0.011	Product	Pounds		7	0.69	Product	Pounds		1
Drainage Ditch Man Made						1	0.004	Product	Gallons		3	0.824	Product	Gallons		4	0.041	Product	Pounds							
Manmade Wetlands																										
Manmade Wetlands Seasonal																										
Wetlands Permanent Treated Effluent																										
Natural Wetlands																										
Natural Wetlands Seasonal																										
Vernal Pool																										
Vernal Pool Manmade																										
Mitigated Wetlands Seasonal																										
Wildlife Refuge																										
Pond	34	0.074	Product	Gallons							5	1.039									1	0.063	Product	Pounds		2
Wildlife Pond											1	0.018	Product	Gallons												
Rain Pond	1	0.007	Product	Gallons							1	0.012	Product	Gallons												
Natural Spring	1	0.005	Product	Gallons																						
Low Area	5	0.505	Product	Gallons							1	0.164	Product	Gallons		1	0.001	Product	Pounds							
Waterways																										
Creeks	8	0.047	Product	Gallons												10	0.253	Product	Pounds		2	0.125	Product	Pounds		
Treehole																										
Culvert	2	0.002	Product	Gallons							1	0.014	Product	Gallons												
Natural Ditch	7	0.105	Product	Gallons							3	0.524	Product	Gallons							1	0.063	Product	Pounds		2
Flood Control Ditch																										
Marshes (Fresh Water)						1	0.5	Product	Gallons																	
Marsh - Seasonal						3	7	Product	Gallons																	
Marsh - Tidal	2	0.014	Product	Gallons		2	0.109	Product	Gallons		1	0.046	Product	Gallons		5	0.226	Product	Pounds							
Cracked Ground																										
Residential Areas																										
Industrial Areas																										
Recreational Areas																										
Agricultural Areas																										
Aeration Pond											4	2.149	Product	Gallons												
Waste Pond	7	2.807	Product	Gallons							19	30.305	Product	Gallons							1	0.063	Product	Pounds		6
Reservoir																										
Settling Pond											6	1.844	Product	Gallons												
Hayfield Ditch	1	0.01	Product	Gallons																						
Pastures																										1
Irrigated Reservoir																					1	0.063	Product	Pounds		
Swamps																										
Overgrown Waste Areas																										
Roadsides																										
Roadside Ditch	5	0.044	Product	Gallons		1	0.005	Product	Gallons		10	1.233	Product	Gallons		4	0.083	Product	Pounds		1	0.063	Product	Pounds		
Woodlands																										
Gardens																										
Playgrounds																										
Campsites																										
Athletic Fields																										
Municipalities																										
Catch Basin	6	0.008	Product	Gallons							35	0.633	Product	Gallons		1	0.002	Product	Pounds							
Waste Treatment Plant											1	0.002	Product	Gallons												
Water Treatment Plant											30	52.823	Product	Gallons												
Wildlife Refuge Treated Effluent																										
Overland Flow																										
Waste Water Irrigation (e.g. pastures)	1	0.25	Product	Gallons		3	16.25	Product	Gallons		3	6.3	Product	Gallons												7
Storm Sewer Line											1	0.012	Product	Gallons												
Storm Water BMP																										
Retention Basin	1	0.01	Active Ingredient	Gallons																						
Sewer Pond	4	1.163	Product	Gallons		1	0.25	Product	Gallons		3	6	Product	Gallons												1
Indoors																										
Total																										
Totals	157	5.789	Mix	Gallons		12	24.118	Product	Gallons		152	107.39	Product	Gallons		27	0.617	Product	Pounds		14	1.13	Product	Pounds		20

Table A17.

Application Sites:	Total Amount Used3345	Total Amount Type3446	Total Amount Unit3447	VectoLex WDG Comments	Zenivex - # Treatments	Total Amount Used3548	Total Amount Type3649	Total Amount Unit3650	Zenivex Comments	Pyrocide Fogging concentrate 7396 - # Treatments	Total Amount Used3144	Total Amount Type3245	Total Amount Unit3246	Pyrocide Fogging concentrate 7396 Comments	VectoBac GS - # Treatments	Total Amount Used3347	Total Amount Type3448	Total Amount Unit3449	VectoBac GS Comments	Altosid Pellets - # Treatments	Total Amount Used111269	Total Amount Type121370	Total Amount Unit121471	Altosid Pellets Comments	Altosid XR Briquets - # Treatments
Anthropogenic Sources	0.063	Product	Pounds							13	0.012	Product	Gallons							55	24.506	Product	Pounds		199
Drainage Ditch Man Made															1	0.2	Product	Gallons		2	0.026	Product	Pounds		1
Manmade Wetlands																									
Manmade Wetlands Seasonal																									
Wetlands Permanent Treated Effluent																									
Natural Wetlands																									
Natural Wetlands Seasonal																									
Vernal Pool																									
Vernal Pool Manmade																									
Mitigated Wetlands Seasonal																									
Wildlife Refuge																									
Pond	0.225	Product	Pounds																	4	0.029	Product	Pounds		103
Wildlife Pond																									
Rain Pond																									
Natural Spring																				2	0.029	Product	Pounds		
Low Area																				5	0.749	Product	Pounds		4
Waterways																									
Creeks																				8	5.469	Product	Pounds		1
Treehole																									
Culvert																									
Natural Ditch	0.813	Product	Pounds																	3	2.39	Product	Pounds		2
Flood Control Ditch																									
Marshes (Fresh Water)																									
Marsh - Seasonal																				1	4.5	Product	Pounds		
Marsh - Tidal															4	2.845	Product	Pounds		5	30.554	Product	Pounds		
Cracked Ground																									
Residential Areas																									
Industrial Areas																									
Recreational Areas																									
Agricultural Areas																									
Aeration Pond																									
Waste Pond	1.25	Product	Pounds												1	0.069	Product	Pounds		2	0.178	Product	Pounds		
Reservoir																									
Settling Pond																									1
Hayfield Ditch																									
Pastures	0.188	Product	Pounds																						
Irrigated Reservoir																									
Swamps																									
Overgrown Waste Areas																									
Roadsides																									
Roadside Ditch																				4	0.35	Product	Pounds		2
Woodlands																									
Gardens																									
Playgrounds																									
Campsites																									
Athletic Fields																									
Municipalities																									
Catch Basin																				6	0.104	Product	Pounds		17
Waste Treatment Plant					1	0.295	Product	Gallons		5	1.173	Product	Gallons							1	0.15	Product	Pounds		2
Water Treatment Plant																									
Wildlife Refuge Treated Effluent																									
Overland Flow																									
Waste Water Irrigation (e.g. pastures)	1.5	Product	Pounds																						1
Storm Sewer Line																									
Storm Water BMP																									1
Retention Basin																				1	0.007	Product	Pounds		1
Sewer Pond	0.86	Product	Pounds																	1	0.415	Product	Pounds		1
Indoors																									
Total																									
Totals	4.899	Product	Pounds		1	0.295	Product	Gallons		18	1.185	Product	Gallons		6	3.114	Product	Pounds		100	69.456	Product	Pounds		336

Table A17.

Application Sites:	Total Amount Used151875	Total Amount Type161976	Total Amount Unit162077	Altosid XR Briquets Comments	Altosid Briquettes (Standard) -# Treatments	Total Amount Used	Total Amount Type2	Total Amount Unit	Altosid Briquettes Comments	Vectolex CG - # Treatments	Total Amount Used3	Total Amount Type4	Total Amount Unit5	Vectolex CG Comments	Vectomax CG - # Treatments	Total Amount Used6	Total Amount Type7	Total Amount Unit8	Vectomax CG Comments	VectoLex WSP - # Treatments	Total Amount Used5	Total Amount Type6	Total Amount Unit7	VectoLex WSP Comments
Anthropogenic Sources	69.547	Product	Pounds	each	24	1.841	Product	Pounds	each	6	0.8	Product	Pounds		10	0.785	Product	Pounds		16	1.034	Product	Pounds	each
Drainage Ditch Man Made	0.111	Product	Pounds	each	1	0.029	Product	Pounds	each	2	0.095	Product	Pounds		1	5	Product	Pounds		1	0.132	Product	Pounds	each
Manmade Wetlands																								
Manmade Wetlands Seasonal																								
Wetlands Permanent Treated Effluent															2	11.6	Product	Pounds						
Natural Wetlands																								
Natural Wetlands Seasonal																								
Vernal Pool																								
Vernal Pool Manmade																								
Mitigated Wetlands Seasonal																								
Wildlife Refuge																								
Pond	18.111	Product	Pounds	each	4	0.086	Product	Pounds	each	4	23.367	Product	Pounds		11	5.304	Product	Pounds		8	0.308	Product	Pounds	each
Wildlife Pond																								
Rain Pond										1	0.5	Product	Pounds		1	1.25	Product	Pounds						
Natural Spring										1	0.8	Product	Pounds											
Low Area	0.667	Product	Pounds	each						1	0.04	Product	Pounds		3	23	Product	Pounds		3	0.066	Product	Pounds	each
Waterways																								
Creeks	0.111	Product	Pounds	each	1	0.029	Product	Pounds	each	3	1.3	Product	Pounds		7	45.93	Product	Pounds		1	0.044	Product	Pounds	each
Treehole																								
Culvert																								
Natural Ditch	0.556	Product	Pounds	each	1	0.014	Product	Pounds	each	1	2	Product	Grams											
Flood Control Ditch																								
Marshes (Fresh Water)																								
Marsh - Seasonal										2	160.5	Product	Pounds		1	1	Product	Pounds						
Marsh - Tidal										1	0.009	Product	Pounds		5	24.75	Product	Pounds						
Cracked Ground																								
Residential Areas																								
Industrial Areas																								
Recreational Areas																								
Agricultural Areas																								
Aeration Pond															1	1.2	Product	Pounds						
Waste Pond										2	22.5	Product	Pounds		21	160.262	Product	Pounds						
Reservoir																								
Settling Pond	0.222	Product	Pounds	each																				
Hayfield Ditch										1	0.5	Product	Pounds											
Pastures										1	5	Product	Pounds											
Irrigated Reservoir																								
Swamps																								
Overgrown Waste Areas																								
Roadsides																								
Roadside Ditch	1	Product	Pounds	each	3	0.057	Product	Pounds	each	3	0.145	Product	Pounds		1	0.046	Product	Pounds		5	0.22	Product	Pounds	each
Woodlands																								
Gardens																								
Playgrounds																								
Campsites																								
Athletic Fields																								
Municipalities																								
Catch Basin	4.611	Product	Pounds	each	30	1.4	Product	Pounds	each	2	0.2	Product	Pounds							28	2.728	Product	Pounds	each
Waste Treatment Plant	0.889	Product	Pounds	each	1	0.014	Product	Pounds	each						2	980.069	Product	Pounds		1	0.022	Product	Pounds	each
Water Treatment Plant																								
Wildlife Refuge Treated Effluent										1	320	Product	Pounds											
Overland Flow																								
Waste Water Irrigation (e.g. pastures)	1.111	Product	Pounds	each						10	197.5	Product	Pounds		1	10	Product	Pounds		1	0.022	Product	Pounds	each
Storm Sewer Line																								
Storm Water BMP	0.111	Product	Pounds	each	1	0.014	Product	Pounds	each															
Retention Basin	0.444	Product	Pounds	each						4	15.772	Product	Pounds		1	0.48	Product	Pounds		1	0.022	Product	Pounds	each
Sewer Pond	0.444	Product	Pounds	each											2	7	Product	Pounds						
Indoors																								
Total																								
Totals	97.935	Product	Pounds	each	66	3.484	Product	Pounds	each	46	751.028	Product	Pounds		70	1277.676	Product	Pounds		65	4.598	Product	Pounds	each

Table A18. **Pesticide Application Data for Winter 2012 – MSMVCD**

Application Sites:	Agnique MMF - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Agnique MMF Comments	VectoBac G - # Treatments	Total Amount Used2	Total Amount Type3	Total Amount Unit3	VectoBac G Comments	VectoBac 12AS - # Treatments	Total Amount Used6	Total Amount Type7	Total Amount Unit7	VectoBac 12AS Comments	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit18	BVA-2 Comments	VectoBac Technical Powder - # Treatments	Total Amount Used19	Total Amount Type20	Total Amount Unit20
Anthropogenic Sources	93	2.381	Product	Gallons							40	11.166	Product	Gallons		9	0.151	Product	Gallons					
Drainage Ditch Man Made	1	0.003	Product	Gallons							12	5.663	Product	Gallons										
Manmade Wetlands																								
Manmade Wetlands Seasonal	1	0.05	Product	Gallons							1	0.031	Product	Gallons										
Wetlands Permanent Treated Effluent											1	1.25	Product	Gallons										
Natural Wetlands																								
Natural Wetlands Seasonal											2	7.75	Product	Gallons		1	25	Product	Gallons					
Vernal Pool	1	0.05	Product	Gallons							4	0.844	Product	Gallons										
Vernal Pool Manmade											3	0.75	Product	Gallons										
Mitigated Wetlands - Seasonal											5	7.925	Product	Gallons										
Wildlife Refuge											1	0.75	Product	Gallons										
Pond	31	0.247	Product	Gallons							17	8.602	Product	Gallons		1	0.25	Product	Gallons					
Dredge Pond											1	1.25	Product	Gallons										
Wildlife Pond																								
Rain Pond	5	0.106	Product	Gallons							23	14.025	Product	Gallons										
Natural Spring	3	0.114	Product	Gallons							1	0.25	Product	Gallons										
Low Area	20	5.114	Product	Gallons							121	80.573	Product	Gallons		4	3.555	Product	Gallons					
Waterways																								
Creeks	5	0.085	Product	Gallons																				
Treehole																								
Culvert											1	0.004	Product	Gallons										
Natural Ditch	2	0.089	Product	Gallons		1	0.18	Product	Pounds		17	8.637	Product	Gallons										
Flood Control Ditch																								
Marshes (Fresh Water)											7	3.779	Product	Gallons										
Marsh - Seasonal											36	93.909	Product	Gallons		2	0.077	Product	Gallons					
Marsh - Tidal	3	0.129	Product	Gallons							15	19.937	Product	Gallons										
Cracked Ground											4	10.001	Product	Gallons										
Residential Areas	661	21.355		0		0	0		0		170	522.089		0		257	98.639				28	0.573		
Industrial Areas																								
Recreational Areas																								
Agricultural Areas																								
Aeration Pond																								
Waste Pond	10	0.324	Product	Gallons							1	0.05	Product	Gallons		2	0.395	Product	Gallons					
Reservoir	1	0.031	Product	Gallons																				
Settling Pond																								
Hayfield Ditch											24	22.5	Product	Gallons										
Pastures																								
Irrigated Reservoir																								
Swamps																								
Overgrown Waste Areas																								
Roadsides																								
Roadside Ditch	11	0.091	Product	Gallons							25	3.704	Product	Gallons		3	0.545	Product	Gallons					
Woodlands																								
Gardens																								
Playgrounds																								
Campsites																								
Athletic Fields																								
Municipalities																								
Catch Basin	1	0.001																						
Waste Treatment Plant	12	0.171	Product	Gallons							3	0.25	Product	Gallons							2	0.645	Product	Pounds
Water Treatment Plant																								
Wildlife Refuge Treated Effluent											1	5.001	Product	Gallons										
Overland Flow																								
Waste Water Irrigation (e.g. pastures)											6	0.422	Product	Gallons										
Storm Sewer Line																								
Storm Water BMP																								
Retention Basin											4	0.519	Product	Gallons										
Sewer Pond																1	2.5	Product	Gallons					
Indoors																								
Total	200	8.986	Product	Gallons		1	0.18	Product	Pounds		376	309.542	Product	Gallons		23	32.473	Product	Gallons		2	0.645	Product	Pounds

Table A18.

Application Sites:	VectoBac Technical Powder Comments	VectoLex WDG - # Treatments	Total Amount Used3345	Total Amount Type3446	Total Amount Unit3447	VectoLex WDG Comments	Pyrocide fogging concentrate 7396 - # Treatments	Total Amount Used3144	Total Amount Type3245	Total Amount Unit3246	Pyrocide fogging concentrate 7396 Comments	VectoBac GS - # Treatments	Total Amount Used3347	Total Amount Type3448	Total Amount Unit3449	VectoBac GS Comments	Altosid Liquid Concentrate - # Treatments	Total Amount Used6966	Total Amount Type71067	Total Amount Unit71168	Altosid Liquid Concentrate Comments	Altosid Pellets - # Treatments
Anthropogenic Sources		4	1.1	Product	Pounds		9	0.027	Product	Gallons		1	0.17	Product	Pounds							24
Drainage Ditch Man Made		1	0.198	Product	Pounds							1	0.028	Product	Pounds							2
Manmade Wetlands																						
Manmade Wetlands Seasonal																						2
Wetlands Permanent Treated Effluent																						
Natural Wetlands																						
Natural Wetlands Seasonal																						
Vernal Pool		1	0.188	Product	Pounds																	
Vernal Pool Manmade		2	1.12	Product	Pounds							1	30	Product	Pounds							
Mitigated Wetlands - Seasonal																						
Wildlife Refuge																						
Pond		1	1.25	Product	Pounds																	3
Dredge Pond																						
Wildlife Pond																						
Rain Pond												1	0.092	Product	Pounds							1
Natural Spring												1	0.068	Product	Pounds							
Low Area		5	4.938	Product	Pounds							6	23.01	Product	Pounds							17
Waterways																						
Creeks																						5
Treehole																						
Culvert																						
Natural Ditch												1	0.092	Product	Pounds							3
Flood Control Ditch																						1
Marshes (Fresh Water)																						1
Marsh - Seasonal																						1
Marsh - Tidal																						10
Cracked Ground																						1
Residential Areas		2	0.133				0	0				2	0.133				5	660		0		170
Industrial Areas																						
Recreational Areas																						
Agricultural Areas																						
Aeration Pond																						
Waste Pond		4	0.54	Product	Pounds																	1
Reservoir																						
Settling Pond																						
Hayfield Ditch		3	13	Product	Pounds												16	2.045	Product	Gallons		2
Pastures																						1
Irrigated Reservoir																						
Swamps																						
Overgrown Waste Areas																						
Roadsides																						
Roadside Ditch												1	0.057	Product	Pounds		2	0.101	Product	Gallons		9
Woodlands																						
Gardens																						
Playgrounds																						
Campsites																						
Athletic Fields																						
Municipalities																						
Catch Basin																						
Waste Treatment Plant																						
Water Treatment Plant																						
Wildlife Refuge Treated Effluent																	1	0.624	Product	Gallons		
Overland Flow																						
Waste Water Irrigation (e.g. pastures)		10	1.469	Product	Pounds																	
Storm Sewer Line																						
Storm Water BMP																						
Retention Basin																						
Sewer Pond																						
Indoors																						
Total		31	23.803	Product	Pounds		9	0.027	Product	Gallons		13	53.517	Product	Pounds		19	2.77	Product	Gallons		84

Table A18.

Application Sites:	Total Amount Used111269	Total Amount Type121370	Total Amount Unit121471	Altosid Pellets Comments	Altosid XR Briquets - # Treatments	Total Amount Used151875	Total Amount Type161976	Total Amount Unit162077	Altosid XR Briquets Comments	Altosid XR-G - # Treatments	Total Amount Used172178	Total Amount Type182279	Total Amount Unit182380	Altosid XR-G Comments	Altosid Briquettes (Standard) -# Treatments	Total Amount Used	Total Amount Type2	Total Amount Unit	Altosid Briquettes Comments	Vectolex CG - # Treatments	Total Amount Used3	Total Amount Type4	Total Amount Unit5	Vectolex CG Comments
Anthropogenic Sources	26.411	Product	Pounds		182	49.769	Product	Pounds	each	1	0.05	Product	Pounds		1	0.014	Product	Pounds	each	4	3.83	Product	Pounds	
Drainage Ditch Man Made	0.206	Product	Pounds																	1	5	Product	Pounds	
Manmade Wetlands																								
Manmade Wetlands Seasonal	0.052	Product	Pounds																	1	50	Product	Pounds	
Wetlands Permanent Treated Effluent																								
Natural Wetlands																								
Natural Wetlands Seasonal																								
Vernal Pool																				7	159.25	Product	Pounds	
Vernal Pool Manmade																				8	309.968	Product	Pounds	
Mitigated Wetlands - Seasonal																				3	112	Product	Pounds	
Wildlife Refuge																								
Pond	1.018	Product	Pounds		73	14.111	Product	Pounds	each											10	146.24	Product	Pounds	
Dredge Pond																								
Wildlife Pond																								
Rain Pond	1.5	Product	Pounds		5	2	Product	Pounds	each											3	90	Product	Pounds	
Natural Spring					1	0.333	Product	Pounds	each															
Low Area	10.064	Product	Pounds		3	1.111	Product	Pounds	each											24	231.205	Product	Pounds	
Waterways							Product	Pounds	each															
Creeks	22.267	Product	Pounds		2	0.222	Product	Pounds	each															
Treehole					1	0.111	Product	Pounds	each															
Culvert																								
Natural Ditch	0.208	Product	Pounds																	2	2.203	Product	Pounds	
Flood Control Ditch	0.113	Product	Pounds																					
Marshes (Fresh Water)	3	Product	Pounds																	2	60	Product	Pounds	
Marsh - Seasonal	44	Product	Pounds																					
Marsh - Tidal	47.868	Product	Pounds																					
Cracked Ground	0.09	Product	Pounds																					
Residential Areas	522.089		0		0	0		0		0	0													
Industrial Areas																								
Recreational Areas																								
Agricultural Areas																								
Aeration Pond																								
Waste Pond	0.3	Product	Pounds																	2	17.9	Product	Pounds	
Reservoir																								
Settling Pond																								
Hayfield Ditch	0.117	Product	Pounds																					
Pastures	0.034	Product	Pounds																					
Irrigated Reservoir																								
Swamps																								
Overgrown Waste Areas																								
Roadsides																								
Roadside Ditch	0.405	Product	Pounds																	8	15.065	Product	Pounds	
Woodlands																								
Gardens																								
Playgrounds																								
Campsites																								
Athletic Fields																								
Municipalities																								
Catch Basin					13	2.556	Active Ingredient	Pounds																
Waste Treatment Plant																								
Water Treatment Plant																								
Wildlife Refuge Treated Effluent																								
Overland Flow																								
Waste Water Irrigation (e.g. pastures)																								
Storm Sewer Line																								
Storm Water BMP																								
Retention Basin																								
Sewer Pond					1	0.222	Active Ingredient	Pounds																
Indoors																								
Total	157.653	Product	Pounds		281	70.435	Active Ingredient	Pounds		1	0.05	Product	Pounds		1	0.014	Product	Pounds		75	1202.661	Product	Pounds	

Table A18.

Application Sites:	Vectomax CG - # Treatments	Total Amount Used6	Total Amount Type7	Total Amount Unit8	Vectomax CG Comments	VectoBac WDG - # Treatments	Total Amount Used2	Total Amount Type3	Total Amount Unit4	VectoBac WDG comments	VectoLex WSP - # Treatments	Total Amount Used5	Total Amount Type6	Total Amount Unit7	VectoLex WSP Comments	Altosid Liquid (non-concentrate) - # Treatments	Total Amount Used8	Total Amount Type9	Total Amount Unit10	Altosid Liquid (non-concentrate) comments
Anthropogenic Sources	1	0.12	Product	Pounds												3	0.788	Product	Gallons	
Drainage Ditch Man Made	4	16.255	Product	Pounds												5	0.531	Active Ingredient	Gallons	
Manmade Wetlands																				
Manmade Wetlands Seasonal	1	10	Product	Pounds							3	0.22	Product	Pounds	each					
Wetlands Permanent Treated Effluent	1	10	Product	Pounds												1	0.156	Product	Gallons	
Natural Wetlands																				
Natural Wetlands Seasonal																				
Vernal Pool	1	10	Product	Pounds																
Vernal Pool Manmade	3	70	Product	Pounds																
Mitigated Wetlands - Seasonal																				
Wildlife Refuge																				
Pond	4	3.748	Product	Pounds							2	0.154	Product	Pounds	each	3	0.765	Product	Gallons	
Dredge Pond																				
Wildlife Pond	1	0.688	Product	Pounds																
Rain Pond	8	69.175	Product	Pounds												5	1.353	Product	Gallons	
Natural Spring	1	0.023	Product	Pounds																
Low Area	45	342.341	Product	Pounds		3	3.565	Product	Pounds							25	5.15	Product	Gallons	
Waterways																				
Creeks																				
Treehole																				
Culvert	1	0.045	Product	Pounds																
Natural Ditch	2	0.2	Product	Pounds												3	0.273	Product	Gallons	
Flood Control Ditch																				
Marshes (Fresh Water)	6	132.05	Product	Pounds												4	0.406	Product	Gallons	
Marsh - Seasonal																6	2.314	Product	Gallons	
Marsh - Tidal	16	163.219	Product	Pounds												7	1.936	Product	Gallons	
Cracked Ground																				
Residential Areas																				
Industrial Areas																				
Recreational Areas																				
Agricultural Areas																				
Aeration Pond																				
Waste Pond	8	24.75	Product	Pounds																
Reservoir																				
Settling Pond	1	0.7	Product	Pounds																
Hayfield Ditch																16	2.045	Product	Gallons	
Pastures																				
Irrigated Reservoir	1	0.1	Product	Pounds																
Swamps																				
Overgrown Waste Areas																				
Roadsides																				
Roadside Ditch	10	21.68	Product	Pounds												2	0.101	Product	Gallons	
Woodlands																				
Gardens																				
Playgrounds																				
Campsites																				
Athletic Fields																				
Municipalities																				
Catch Basin											1	0.198	Product	Pounds	each					
Waste Treatment Plant																				
Water Treatment Plant																				
Wildlife Refuge Treated Effluent																1	0.624	Product	Gallons	
Overland Flow																				
Waste Water Irrigation (e.g. pastures)	4	5.6	product	pounds																
Storm Sewer Line																				
Storm Water BMP																				
Retention Basin																				
Sewer Pond	5	56.25	Product	pounds																
Indoors																				
Total	124	936.944	Product	Pounds		3	3.565	Product	Pounds		6	0.572	Product	Pounds	each	81	16.442	Product	Gallons	

Table A19. **Pesticide Application Data for Spring2012 – MSMVCD**

Application Sites:	Agnique MMF - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Agnique MMF Comments	Agnique MMF G - # Treatments	Total Amount Used4	Total Amount Type5	Total Amount Unit5	Agnique MMF G Comments	VectoBac 12AS - # Treatments	Total Amount Used6	Total Amount Type7	Total Amount Unit7	VectoBac 12AS Comments	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit18	BVA-2 Comments	VectoBac Technical Powder - # Treatments	Total Amount Used19	Total Amount Type20	Total Amount Unit20
Anthropogenic Sources	212	1.434	Product	Gallons							9	11.952	Product	Gallons		44	1.758	Product	Gallons		2	0.025	Product	Pounds
Drainage Ditch Man Made	9	0.24	Product	Gallons							7	40.625	Product	Gallons		6	0.21	Product	Gallons		2	0.001	Product	Pounds
Manmade Wetlands																								
Manmade Wetlands Seasonal											5	4.925	Product	Gallons										
Wetlands Permanent Treated Effluent						4	399	Product	Pounds		1	1.25	Product	Gallons										
Natural Wetlands																								
Natural Wetlands Seasonal																								
Vernal Pool											1	0.063	Product	Gallons										
Vernal Pool Manmade	1	0.009									2	0.896	Product	Gallons		1	5	Product	Gallons					
Mitigated Wetlands Seasonal																								
Wildlife Refuge											2	4.367	Product	Gallons										
Pond	225	4.985	Product	Gallons							6	5.666	Product	Gallons		5	5.018	Product	Gallons					
Dredge Pond																								
Wildlife Pond																								
Rain Pond	6	0.628	Product	Gallons							11	27.484	Product	Gallons		1	1	Product	Gallons		1	0.059	Product	Pounds
Natural Spring	3	0.04	Product	Gallons																				
Low Area	35	8.908	Product	Gallons							53	147.205	Product	Gallons		13	14.807	Product	Gallons		2	0.004	Product	Pounds
Waterways																								
Creeks	22	0.753	Product	Gallons							8	0.568	Product	Gallons		4	0.188	Product	Gallons		6	0.089	Product	Pounds
Treehole	1	0.005	Product	Gallons																				
Culvert	1	0.001	Product	Gallons												1	0.035	Product	Gallons					
Natural Ditch	10	0.533	Product	Gallons							8	2.854	Product	Gallons		10	5.966	Product	Gallons					
Flood Control Ditch																1	0.006	Product	Gallons					
Marshes (Fresh Water)	3	0.033	Product	Gallons							5	2.41	Product	Gallons							1	0.086	Product	Pounds
Marsh - Seasonal											17	105.89	Product	Gallons		1	0.469	Product	Gallons		2	0.215	Product	Pounds
Marsh - Tidal	4	0.059	Product	Gallons							8	156.029	Product	Gallons							4	0.035	Product	Pounds
Cracked Ground																								
Residential Areas																								
Industrial Areas																								
Recreational Areas																								
Agricultural Areas																								
Aeration Pond	2	0.002	Product	Gallons																				
Waste Pond	31	1.758	Product	Gallons							1	0.031	Product	Gallons		22	44.661	Product	Gallons					
Reservoir																								
Settling Pond	2	0.11	Product	Gallons												1	0.023	Product	Gallons					
Hayfield Ditch											11	6.25	Product	Gallons										
Pastures																								
Irrigated Reservoir																								
Swamps																								
Overgrown Waste Areas																								
Roadsides																								
Roadside Ditch	25	0.473	Product	Gallons							8	1.323	Product	Gallons		26	2.755	Product	Gallons		8	0.059	Product	Pounds
Woodlands																								
Gardens																								
Playgrounds																								
Campsites																								
Athletic Fields																								
Municipalities																								
Catch Basin	28	0.048	Product	Gallons							2	0.001	Product	Gallons		110	4.835	Product	Gallons					
Waste Treatment Plant	35	0.709	Product	Gallons												2	0.163	Product	Gallons					
Water Treatment Plant																6	10.62	Product	Gallons					
Wildlife Refuge Treated Effluent																								
Overland Flow																								
Waste Water Irrigation (e.g. pastures)	2	0.007	Product	Gallons							2	0.2	Product	Gallons										
Storm Sewer Line																								
Storm Water BMP																								
Retention Basin											2	1.35	Product	Gallons										
Sewer Pond	4	0.62	Product	Gallons		1	261	Product	Pounds		1	0.75	Product	Gallons		3	1.125	Product	Gallons					
Indoors																								
Totals	661	21.355	Product	Gallons		5	660	Product	Pounds		170	522.089	Product	Gallons		257	98.639	Product	Gallons		28	0.573	Product	Pounds

Table A19.

Application Sites:	VectoBac Technical Powder Comments	Wasp Freeze - # Treatments	Total Amount Used33	Total Amount Type34	Total Amount Unit34	Wasp Freeze Comments	Drione - # Treatments	Total Amount Used1112	Total Amount Type1213	Total Amount Unit1214	Drione Comments	FourStar 45 - # Treatments	Total Amount Used2127	Total Amount Type2228	Total Amount Unit2229	FourStar 45 Comments	VectoLex WDG - # Treatments	Total Amount Used3345	Total Amount Type3446	Total Amount Unit3447	VectoLex WDG Comments	Pyrocide fogging concentrate 7067 - # Treatments	Total Amount Used2535	Total Amount Type2636
Anthropogenic Sources		1	0.008	Product	Pounds							1	0.21	Active Ingredient	Pounds		5	3.5	Product	Pounds		9	0.22	Product
Drainage Ditch Man Made																	3	0.255	Product	Pounds		2	0.328	Product
Manmade Wetlands																								
Manmade Wetlands Seasonal																								
Wetlands Permanent Treated Effluent																						8	0.938	Product
Natural Wetlands																								
Natural Wetlands Seasonal																								
Vernal Pool																	2	0.563	Product	Pounds				
Vernal Pool Manmade																	3	3.725	Product	Pounds				
Mitigated Wetlands Seasonal																								
Wildlife Refuge																								
Pond							2	0.125	Product	Pounds												7	0.375	Product
Dredge Pond																								
Wildlife Pond																								
Rain Pond																								
Natural Spring																								
Low Area																	1	0.325	Product	Pounds		10	0.483	Product
Waterways																								
Creeks																	8	1.506	Product	Pounds		2	0.288	Product
Treehole																						1	2.082	Product
Culvert																	1	0.01	Product	Pounds				
Natural Ditch																								
Flood Control Ditch																	1	0.015	Product	Pounds				
Marshes (Fresh Water)																	1	2	Product	Pounds				
Marsh - Seasonal		1	0.125	Product	Pounds												1	0.5	Product	Pounds				
Marsh - Tidal																								
Cracked Ground																								
Residential Areas																								
Industrial Areas																								
Recreational Areas																								
Agricultural Areas																								
Aeration Pond																								
Waste Pond																	4	2.838	Product	Pounds				
Reservoir																								
Settling Pond																								
Hayfield Ditch																	3	32	Product	Pounds		1	0.563	Product
Pastures																								
Irrigated Reservoir																								
Swamps																								
Overgrown Waste Areas																								
Roadsides																								
Roadside Ditch																								
Woodlands																								
Gardens																								
Playgrounds																								
Campsites																								
Athletic Fields																								
Municipalities																								
Catch Basin																								
Waste Treatment Plant																						4	0.859	Product
Water Treatment Plant																								
Wildlife Refuge Treated Effluent																								
Overland Flow																								
Waste Water Irrigation (e.g. pastures)																	10	1.625	Product	Pounds				
Storm Sewer Line																								
Storm Water BMP																								
Retention Basin																								
Sewer Pond																	2	3.248	Product	Pounds		4	0.656	Product
Indoors																								
Totals		2	0.133	Product	Pounds		2	0.125	Product	Pounds		1	0.21	Active Ingredient	Pounds		45	52.11	Product	Pounds		48	6.792	Product

Table A19.

Application Sites:	Total Amount Unit2637	Pyrocide fogging concentrate 7067 Comments	VectoBac GS - # Treatments	Total Amount Used3347	Total Amount Type3448	Total Amount Unit3449	VectoBac GS Comments	Altosid Liquid Concentrate - # Treatments	Total Amount Used6966	Total Amount Type71067	Total Amount Unit71168	Altosid Liquid Concentrate Comments	Altosid Pellets - # Treatments	Total Amount Used111269	Total Amount Type121370	Total Amount Unit121471	Altosid Pellets Comments	Altosid SBG - # Treatments	Total Amount Used131572	Total Amount Type141673	Total Amount Unit141774	Altosid SBG Comments	Altosid XR Briquets - # Treatments	Total Amount Used151875
Anthropogenic Sources	Gallons												73	37.604	Product	Pounds							484	127.783
Drainage Ditch Man Made	Gallons							1	2.465	Product	Gallons												5	1.222
Manmade Wetlands																								
Manmade Wetlands Seasonal													1	0.103	Product	Pounds								
Wetlands Permanent Treated Effluent	Gallons																							
Natural Wetlands																								
Natural Wetlands Seasonal			1	800	Product	Pounds																		
Vernal Pool																								
Vernal Pool Manmade																								
Mitigated Wetlands Seasonal													1	2.5	Product	Pounds								
Wildlife Refuge																								
Pond	Gallons							1	0.322	Product	Gallons		14	0.52	Product	Pounds							414	76.777
Dredge Pond																								
Wildlife Pond																								
Rain Pond			2	6.5	Product	Pounds		2	1.013	Product	Gallons		6	3.359	Product	Pounds							4	1.333
Natural Spring													2	1.046	Active Ingredient	Pounds							1	0.222
Low Area	Gallons		4	22.557	Product	Gallons		2	4.366	Product	Gallons		36	101.037	Product	Pounds		1	40	Product	Pounds			
Waterways																								
Creeks	Gallons		1	1.25	Product	Pounds							47	33.522	Product	Pounds							11	3.778
Treehole	Gallons																						1	0.111
Culvert													3	0.042	Product	Pounds							1	0.222
Natural Ditch			2	1.046	Product	Pounds							5	1.196	Product	Pounds							3	0.667
Flood Control Ditch			2	1.7									3	0.246	Product	Pounds								
Marshes (Fresh Water)			1	14	Product	Pounds							5	6.25	Product	Pounds								
Marsh - Seasonal			4	12.5	Product	Pounds		5	5.799	Product	Gallons		8	436.75	Product	Pounds		1	120	Product	Pounds			
Marsh - Tidal			2	10	Product	Pounds		3	5.059	Product	Gallons		40	1243.028	Product	Pounds								
Cracked Ground													1	9	Product	Pounds		1	40	Product	Pounds			
Residential Areas																								
Industrial Areas																								
Recreational Areas																								
Agricultural Areas																								
Aeration Pond																								
Waste Pond													3	1.055	Product	Pounds							1	0.222
Reservoir													2	0.135	Product	Pounds								
Settling Pond																								
Hayfield Ditch	Gallons																							
Pastures																								
Irrigated Reservoir																								
Swamps																								
Overgrown Waste Areas																								
Roadsides																								
Roadside Ditch			2	0.16	Product	Pounds							21	2.873	Product	Pounds							3	0.333
Woodlands																								
Gardens																								
Playgrounds																								
Campsites																								
Athletic Fields																								
Municipalities																								
Catch Basin													10	0.055	Product	Pounds							529	186.465
Waste Treatment Plant	Gallons												2	0.75	Product	Pounds							1	0.778
Water Treatment Plant																								
Wildlife Refuge Treated Effluent																								
Overland Flow																								
Waste Water Irrigation (e.g. pastures)													3	6.45	Product	Pounds								
Storm Sewer Line																								
Storm Water BMP																								
Retention Basin			1	5	Product	Pounds							1	0.2	Product	Pounds								
Sewer Pond	Gallons		2	8.3	Product	Pounds							4	4.05	Product	Pounds							1	0.667
Indoors																								
Totals	Gallons		24	883.013	Product	Pounds		14	19.024	Product	Gallons		291	1891.771	Product	Pounds		3	200	Product	Pounds		1459	400.58

Table A19.

Application Sites:	Total Amount Type161976	Total Amount Unit162077	Altosid XR Briquets Comments	Altosid XR-G - # Treatments	Total Amount Used172178	Total Amount Type182279	Total Amount Unit182380	Altosid XR-G Comments	Altosid Briquettes (Standard) -# Treatments	Total Amount Used	Total Amount Type2	Total Amount Unit	Altosid Briquettes Comments	Vectolex CG - # Treatments	Total Amount Used3	Total Amount Type4	Total Amount Unit5	Vectolex CG Comments	Vectomax CG - # Treatments	Total Amount Used6	Total Amount Type7	Total Amount Unit8	Vectomax CG Comments	VectoBac WDG - # Treatments
Anthropogenic Sources	Product	Pounds	each						9	0.172	Product	Pounds	each	13	40.11	Product	Pounds		18	32.151	Product	Pounds		
Drainage Ditch Man Made	Product	Pounds	each						1	0.014	Product	Pounds	each	8	23.991	Product	Pounds		5	425.04	Product	Pounds		2
Manmade Wetlands																								
Manmade Wetlands Seasonal									8	1.8	Product	Pounds	each	18	440.5	Product	Pounds		1	60	Product	Pounds		
Wetlands Permanent Treated Effluent																			17	897.6	Product	Pounds		
Natural Wetlands																								
Natural Wetlands Seasonal														5	1092.5	Product	Pounds		3	1560	Product	Pounds		
Vernal Pool														9	184	Product	Pounds		2	60	Product	Pounds		
Vernal Pool Manmade														29	1422.5	Product	Pounds		1	30	Product	Pounds		
Mitigated Wetlands Seasonal														2	190	Product	Pounds		1	2.5	Product	Pounds		
Wildlife Refuge																			1	160	Product	Pounds		
Pond	Product	Pounds	each	1	0.001	Product	Pounds		14	0.286	Product	Pounds	each	10	23.086	Product	Pounds		9	4.951	Product	Pounds		
Dredge Pond																								
Wildlife Pond																								
Rain Pond	Product	Pounds	each											5	89.75	Product	Pounds		4	33.046	Product	Pounds		
Natural Spring	Product	Pounds	each											2	20	Product	Pounds		4	0.318	Product	Pounds		
Low Area														59	808.762	Product	Pounds		29	319.209	Product	Pounds		
Waterways																								
Creeks	Product	Pounds	each						2	0.057	Product	Pounds	each	6	34.213	Product	Pounds		9	22.7	Product	Pounds		
Treehole	Product	Pounds	each																					
Culvert	Product	Pounds	each																					
Natural Ditch	Product	Pounds	each											9	78.637	Product	Pounds		6	31.004	Product	Pounds		
Flood Control Ditch																								
Marshes (Fresh Water)														6	250	Product	Pounds		1	2.3	Product	Pounds		
Marsh - Seasonal														2	20	Product	Pounds		1	0.04	Product	Pounds		
Marsh - Tidal														1	10	Product	Pounds		6	85.758	Product	Pounds		
Cracked Ground																								
Residential Areas																								
Industrial Areas																								
Recreational Areas																								
Agricultural Areas																								
Aeration Pond																								
Waste Pond	Product	Pounds	each											7	45.956	Product	Pounds		22	124.3	Product	Pounds		3
Reservoir																								
Settling Pond														1	2.5	Product	Pounds							
Hayfield Ditch														1	15	Product	Pounds		2	40	Product	Pounds		
Pastures														1	15	Product	Pounds							
Irrigated Reservoir														3	20.013	Product	Pounds							
Swamps																								
Overgrown Waste Areas																								
Roadsides																								
Roadside Ditch	Product	Pounds	each						2	0.043	Product	Pounds	each	8	4.416	Product	Pounds		10	0.943	Product	Pounds		
Woodlands																								
Gardens																								
Playgrounds																								
Campsites																								
Athletic Fields																								
Municipalities																								
Catch Basin	Product	Pounds	each						9	0.457	Product	Pounds	each	1	0.01	Product	Pounds							
Waste Treatment Plant	Product	Pounds	each											3	22.5	Product	Pounds							
Water Treatment Plant																								
Wildlife Refuge Treated Effluent																								
Overland Flow																								
Waste Water Irrigation (e.g. pastures)														15	107.9	Product	Pounds		27	125.3	Product	Pounds		
Storm Sewer Line																								
Storm Water BMP																								
Retention Basin														4	26.48	Product	pounds		2	45.04	Product	pounds		
Sewer Pond	Product	Pounds	each																10	1918	Product	Pounds		
Indoors																								
Totals	Product	Pounds	each	1	0.001	Product	Pounds		45	2.829	Product	Pounds		228	4987.824	Product	Pounds		191	5980.2	Product	Pounds		5

Table A19.

Application Sites:	Total Amount Used2	Total Amount Type3	Total Amount Unit4	VectoBac WDG comments	VectoLex WSP - # Treatments	Total Amount Used5	Total Amount Type6	Total Amount Unit7	VectoLex WSP Comments	Altosid Liquid (non-concentrate) - # Treatments	Total Amount Used8	Total Amount Type9	Total Amount Unit10	Altosid Liquid (non-concentrate) comments	FourStar SBG - # Treatments	Total Amount Used11	Total Amount Type12	Total Amount Unit13	FourStar SBG comments
Anthropogenic Sources					22	1.122	Product	Pounds	each	1	1.369	Product	Gallons						
Drainage Ditch Man Made	0.188	Product	Pounds		1	0.0025	Product	Pounds	each	1	0.203	Product	Gallons						
Manmade Wetlands																			
Manmade Wetlands Seasonal										1	0.053	Product	Gallons						
Wetlands Permanent Treated Effluent										1	0.156	Product	Gallons						
Natural Wetlands																			
Natural Wetlands Seasonal																			
Vernal Pool																			
Vernal Pool Manmade										1	0.018	Product	Gallons						
Mitigated Wetlands Seasonal																			
Wildlife Refuge										2	0.545	Product	Gallons						
Pond					15	0.385	Product	Pounds	each	1	0.008	Product	Gallons						
Dredge Pond																			
Wildlife Pond																			
Rain Pond										7	1.454	Product	Gallons						
Natural Spring																			
Low Area					1	0.022	Product	Pounds	each	33	9.133	Product	Gallons						
Waterways																			
Creeks					2	0.154	Product	Pounds	each	2	0.031	Product	Gallons						
Treehole																			
Culvert																			
Natural Ditch										5	0.437	Product	Gallons						
Flood Control Ditch					1	0.044	Product	Pounds	each										
Marshes (Fresh Water)										3	0.254	Product	Gallons						
Marsh - Seasonal										6	1.267	Product	Gallons		3	120	Product	Pounds	
Marsh - Tidal										3	1.717	Product	Gallons						
Cracked Ground										1	0.156	Product	Gallons						
Residential Areas																			
Industrial Areas																			
Recreational Areas																			
Agricultural Areas																			
Aeration Pond																			
Waste Pond	0.613	Product	Pounds																
Reservoir																			
Settling Pond																			
Hayfield Ditch										11	101.144	Product	Pounds						
Pastures																			
Irrigated Reservoir																			
Swamps																			
Overgrown Waste Areas																			
Roadsides																			
Roadside Ditch					1	0.022	Product	Pounds	each	2	0.156	Product	Gallons						
Woodlands																			
Gardens																			
Playgrounds																			
Campsites																			
Athletic Fields																			
Municipalities																			
Catch Basin					24	1.958	Product	Pounds	each										
Waste Treatment Plant																			
Water Treatment Plant																			
Wildlife Refuge Treated Effluent										1	0.078	Product	Gallons						
Overland Flow																			
Waste Water Irrigation (e.g. pastures)																			
Storm Sewer Line																			
Storm Water BMP																			
Retention Basin										1	0.156	Product	Gallons						
Sewer Pond										1	0.094	Product	Gallons						
Indoors																			
Totals	0.801	Product	Pounds		67	3.7095	Product	Pounds	each	84	118.429	Product	Gallons		3	120	Product	Pounds	

Table A20. Pesticide Product Key – MSMVCD

Product	AI
Agnique MMF G	Biodegradable Alcohol Ethoxylated Surfactant
Agnique MMF Mosquito Larvicide & Pupicide	Biodegradable Alcohol Ethoxylated Surfactant
BVA 2 Mosquito Larvicide Oil	Petroleum Distillate
Delta Dust Insecticide	Deltamethrin
Drione Insecticide	Pyrethrin and Piperonyl Butroxide and Amorphous Silica Gel
FourStar 45	Bacillus Sphaericus and Bacillus Thuringiensis Israelensis
FourStar SBG	Bacillus Thuringiensis Israelensis
Pyrocide Mosquito Adulticiding Concentrate for ULV Fogging 7067	Pyrethrin and Piperonyl Butoxide
Pyrocide Mosquito Adulticiding Concentrate for ULV Fogging 7396	Pyrethrin and Piperonyl Butoxide
VectoBac 12AS Biological Larvicide	Bacillus Thuringiensis Israelensis
VectoBac G Biological Larvicide	Bacillus Thuringiensis Israelensis
VectoBac GS Biological Larvicide	Bacillus Thuringiensis Israelensis
VectoBac Technical Powder Biological Larvicide	Bacillus Thuringiensis Israelensis
VectoBac WDG Biological Larvicide	Bacillus Thuringiensis Israelensis
VectoLex WDG Biological Larvicide	Bacillus Sphaericus
VectoLex WSP Biological Larvicide	Bacillus Sphaericus
VectoMax CG Biological Larvicide	Bacillus Sphaericus and Bacillus Thuringiensis Israelensis
Wasp Freeze	Phenothrin and Trans Allethrin
Zenivex E20	Etofenprox
Zoecon Altosid Briquets	Methoprene
Zoecon Altosid Liquid Larvicide Concentrate	Methoprene
Zoecon Altosid Liquid Larvicide Mosquito Growth Regulator	Methoprene
Zoecon Altosid Pellets	Methoprene
Zoecon Altosid SBG Single Brood Granule	Methoprene
Zoecon Altosid XR Entended Residual Briquets	Methoprene
Zoecon Altosid XR-G	Methoprene

Table A21. **Pesticide Application Data for Summer 2011 – NCMAD**

Application Sites:	5% Skeeter Abate - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	5% Skeeter Abate Comments	Teknar HP-D - # Treatments	Total Amount Used4	Total Amount Type5	Total Amount Unit5	Teknar HP-D Comments	Altosid Liquid SR5 - # Treatments	Total Amount Used11	Total Amount Type12	Total Amount Unit12	Altosid Liquid SR5 Comments	Altosid Pellets - # Treatments	Total Amount Used15	Total Amount Type16
1. Tidal marsh						4	800	Product	Ounces (volume)		4	200	Product	Ounces (volume)				
2. Fresh water marsh	3	360	Product	Ounces (weight)		3	320	Product	Ounces (volume)		3	80	Product	Ounces (volume)		2	400	Product
2A. Reclaimed Marsh						3	560	Product	Ounces (volume)		3	140	Product	Ounces (volume)				
3. Diked marsh																		
4. Seasonal wetland	5	109	Product	Ounces (weight)		4	240	Product	Ounces (volume)		4	60	Product	Ounces (volume)		4	141	Product
4A. Seasonal Vineyard Water/Pothole																		
5. Natural seep																		
6. River margin																		
7. Creek																		
8. Seasonal creek pools	2	6	Product	Ounces (weight)														
9. Channel (unlined)	16	176	Product	Ounces (weight)		13	880	Product	Ounces (volume)		13	220	Product	Ounces (volume)		11	174	Product
10. Ditch																		
10A. Agricultural Ditch						1	160	Product	Ounces (volume)		1	40	Product	Ounces (volume)		2	176	Product
11. Vernal pool																		
12. Flooded/irrigated pasture	1	4	Product	Ounces (weight)														
13. Storm drain/catch basin	15	44	Product	Ounces (weight)		22	1166	Product	Ounces (volume)		22	296	Product	Ounces (volume)		7	21	Product
14. Waste water pond	3	181	Product	Ounces (weight)							1	4	Product	Ounces (volume)		1	32	Product
14A. Waste Water Spray Field/Marsh						3	240	Product	Ounces (volume)		4	70	Product	Ounces (volume)		4	624	Product
15. Winery waste pond																		
16. Stock pond																		
17. Irrigation pond/Vineyard Pond																		
18. Storm water detention basin																2	56	Product
19. Sump	6	40	Product	Ounces (weight)												3	365	Product
20. Septic tank	6	36	Product	Ounces (weight)												7	65	Product
21. Ornamental water garden/fish pond	1	10	Product	Ounces (weight)														
22. Swimming pool																		
23. Spa/hot tub																		
24. Man-made container (e.g. buckets, tires, cemetery urns, wading pools, wheel barrow, etc)	22	147	Product	Ounces (weight)												9	126	Product
24A. Agrcultural Containers (e.g. bins, etc.)																		
25. Tree holes																		
26. Horse/livestock watering troughs																		
27. Water under buildings	2	13	Product	Ounces (weight)														
28. Utility vaults																		
29. Dredge Disposal Pond																		
30. Wells/Water Storage Tanks/Pumps																		
31. Water Main Leaks	1	80	Product	Ounces (weight)														
32. Other Natural Water Sources	1	10	Product	Ounces (weight)														
33. Other Commercial Sources																		
34. Other																		
35. Fresh Water Pond (Natural)	6	704	Product	Ounces (weight)												1	8	Product
36. Cess Pool																		
Total	90	1920	Product	Ounces (weight)		53	4366	Product	Ounces (volume)		55	1110	Product	Ounces (volume)		53	2188	Product

Table A21.

Application Sites:	Total Amount Unit16	Altosid Pellets Comments	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit18	BVA-2 Comments	VectoLex CG - # Treatments	Total Amount Used19	Total Amount Type20	Total Amount Unit20	VectoLex CG Comments	VectoMax WSP - # Treatments	Total Amount Used21	Total Amount Type22	Total Amount Unit22	VectoMax WSP Comments	Altosid Briquets 30-day - # Treatments
1. Tidal marsh																		
2. Fresh water marsh	Ounces (weight)																	
2A. Reclaimed Marsh																		
3. Diked marsh																		
4. Seasonal wetland	Ounces (weight)																	
4A. Seasonal Vineyard Water/Pothole																		
5. Natural seep																		
6. River margin																		
7. Creek																		
8. Seasonal creek pools																		
9. Channel (unlined)	Ounces (weight)							3	21	Product	Ounces (weight)		5	18	Product	her (specify in comments secti	Each	1
10. Ditch																		
10A. Agricultural Ditch	Ounces (weight)																	
11. Vernal pool																		
12. Flooded/irrigated pasture																		
13. Storm drain/catch basin	Ounces (weight)		3	16	Product	Ounces (volume)							43	2261	Product	her (specify in comments secti	Each	25
14. Waste water pond	Ounces (weight)		1	128	Product	Ounces (volume)							2	24	Product	her (specify in comments secti	Each	
14A. Waste Water Spray Field/Marsh	Ounces (weight)		1	1280	Product	Ounces (volume)												
15. Winery waste pond																		
16. Stock pond																		
17. Irrigation pond/Vineyard Pond																		
18. Storm water detention basin	Ounces (weight)																	1
19. Sump	Ounces (weight)												1	15	Product	her (specify in comments secti	Each	1
20. Septic tank	Ounces (weight)												3	1	Product	her (specify in comments secti	Each	1
21. Ornamental water garden/fish pond													1	1	Product	her (specify in comments secti	Each	
22. Swimming pool													1	16	Product	her (specify in comments secti	Each	
23. Spa/hot tub			2	18	Product	Ounces (volume)												
24. Man-made container (e.g. buckets, tires, cemetery urns, wading pools, wheel barrow, etc)	Ounces (weight)		2	5	Product	Ounces (volume)							13	106	Product	her (specify in comments secti	Each	13
24A. Agrcultural Containers (e.g. bins, etc.)																		
25. Tree holes																		
26. Horse/livestock watering troughs																		
27. Water under buildings			2	28	Product	Ounces (volume)												
28. Utility vaults																		1
29. Dredge Disposal Pond																		
30. Wells/Water Storage Tanks/Pumps																		
31. Water Main Leaks																		
32. Other Natural Water Sources																		6
33. Other Commercial Sources																		7
34. Other																		
35. Fresh Water Pond (Natural)	Ounces (weight)																	
36. Cess Pool			2	134	Product	Ounces (volume)							1	1	Product	her (specify in comments secti	Each	
Total	Ounces (weight)		13	1609	Product	Ounces (volume)		3	21	Product	Ounces (weight)		70	2443	Product	her (specify in comments secti	Each	56

Table A21.

Application Sites:	Total Amount Used23	Total Amount Type24	Total Amount Unit24	Altosid Briquets 30 Day Commnets	Permanone - # Treatments	Total Amount Used25	Total Amount Type26	Total Amount Unit26	Permanone Comments	MGK Pyrocide 7396 - # Treatments	Total Amount Used27	Total Amount Type28	Total Amount Unit28	MGK Pyrocide 7396 Comments	Pyrenone 25-5 - # Treatments	Total Amount Used29	Total Amount Type30	Total Amount Unit30
1. Tidal marsh																		
2. Fresh water marsh																		
2A. Reclaimed Marsh					1	375	Product	Ounces (volume)										
3. Diked marsh																		
4. Seasonal wetland																		
4A. Seasonal Vineyard Water/Pothole																		
5. Natural seep																		
6. River margin																		
7. Creek																		
8. Seasonal creek pools																		
9. Channel (unlined)	5	Product	er (specify in comments sect	Each														
10. Ditch																		
10A. Agricultural Ditch																		
11. Vernal pool																		
12. Flooded/irrigated pasture																		
13. Storm drain/catch basin	4092	Product	er (specify in comments sect	Each														
14. Waste water pond																		
14A. Waste Water Spray Field/Marsh																		
15. Winery waste pond																		
16. Stock pond																		
17. Irrigation pond/Vineyard Pond																		
18. Storm water detention basin	10	Product	er (specify in comments sect	Each														
19. Sump	4	Product	er (specify in comments sect	Each														
20. Septic tank	6	Product	er (specify in comments sect	Each														
21. Ornamental water garden/fish pond																		
22. Swimming pool																		
23. Spa/hot tub																		
24. Man-made container (e.g. buckets, tires, cemetery urns, wading pools, wheel barrow, etc)	69	Product	er (specify in comments sect	Each														
24A. Agrcultural Containers (e.g. bins, etc.)																		
25. Tree holes										38	2140	Product	Ounces (volume)		2	80	Product	Ounces (volume)
26. Horse/livestock watering troughs																		
27. Water under buildings															2	2	Product	Ounces (volume)
28. Utility vaults	5	Product	er (specify in comments sect	Each														
29. Dredge Disposal Pond																		
30. Wells/Water Storage Tanks/Pumps																		
31. Water Main Leaks																		
32. Other Natural Water Sources	17	Product	er (specify in comments sect	Each														
33. Other Commercial Sources	55	Product	er (specify in comments sect	Each														
34. Other																		
35. Fresh Water Pond (Natural)																		
36. Cess Pool																		
Total	4263	Product	er (specify in comments sect	Each	1	375	Product	Ounces (volume)		38	2140	Product	Ounces (volume)		4	82	Product	Ounces (volume)

Table A21.

Application Sites:	Pyrenone 25-5 Comments	Wasp Freeze - # Treatments	Total Amount Used33	Total Amount Type34	Total Amount Unit34	Wasp Freeze Comments	Drione Insecticide - # Treatments	Total Amount Used35	Total Amount Type36	Total Amount Unit36	Drione Comments	Contrac All-Weather Blox - # Treatments	Total Amount Used39	Total Amount Type40	Total Amount Unit40	Contrac Blox Comments	GB1111 Larv. Oil # Treatments	Total Amount Used
1. Tidal marsh																		
2. Fresh water marsh																		
2A. Reclaimed Marsh																		
3. Diked marsh																		
4. Seasonal wetland																		
4A. Seasonal Vineyard Water/Pothole																		
5. Natural seep																		
6. River margin																		
7. Creek																		
8. Seasonal creek pools																		
9. Channel (unlined)																	2	33
10. Ditch																		
10A. Agricultural Ditch																		
11. Vernal pool																		
12. Flooded/irrigated pasture																		
13. Storm drain/catch basin																	4	16
14. Waste water pond																	7	1200
14A. Waste Water Spray Field/Marsh																	3	2304
15. Winery waste pond																		
16. Stock pond																		
17. Irrigation pond/Vineyard Pond																		
18. Storm water detention basin																	2	25
19. Sump																	1	3
20. Septic tank																	4	22
21. Ornamental water garden/fish pond																	1	6
22. Swimming pool																	2	13
23. Spa/hot tub																		
24. Man-made container (e.g. buckets, tires, cemetery urns, wading pools, wheel barrow, etc)																	7	21
24A. Agrcultural Containers (e.g. bins, etc.)																		
25. Tree holes																		
26. Horse/livestock watering troughs																		
27. Water under buildings																		
28. Utility vaults																		
29. Dredge Disposal Pond																		
30. Wells/Water Storage Tanks/Pumps																		
31. Water Main Leaks																		
32. Other Natural Water Sources																		
33. Other Commercial Sources												1	50	Product	er (specify in comments sect	Each		
34. Other		7	34	Product	Ounces (volume)		233	465	Product	Ounces (weight)		22	288	Product	er (specify in comments sect	Each		
35. Fresh Water Pond (Natural)																		
36. Cess Pool																		
Total		7	34	Product	Ounces (volume)		233	465	Product	Ounces (weight)		23	338	Product	er (specify in comments sect	Each	33	3643

Table A21.

Application Sites:	Total Amount Type2	Total Amount Unit	GB1111 Larv Oil. Comments
1. Tidal marsh			
2. Fresh water marsh			
2A. Reclaimed Marsh			
3. Diked marsh			
4. Seasonal wetland			
4A. Seasonal Vineyard Water/Pothole			
5. Natural seep			
6. River margin			
7. Creek			
8. Seasonal creek pools			
9. Channel (unlined)	Product	Ounces (volume)	
10. Ditch			
10A. Agricultural Ditch			
11. Vernal pool			
12. Flooded/irrigated pasture			
13. Storm drain/catch basin	Product	Ounces (volume)	
14. Waste water pond	Product	Ounces (volume)	
14A. Waste Water Spray Field/Marsh	Product	Ounces (volume)	
15. Winery waste pond			
16. Stock pond			
17. Irrigation pond/Vineyard Pond			
18. Storm water detention basin	Product	Ounces (volume)	
19. Sump	Product	Ounces (volume)	
20. Septic tank	Product	Ounces (volume)	
21. Ornamental water garden/fish pond	Product	Ounces (volume)	
22. Swimming pool	Product	Ounces (volume)	
23. Spa/hot tub			
24. Man-made container (e.g. buckets, tires, cemetery urns, wading pools, wheel barrow, etc)	Product	Ounces (volume)	
24A. Agrcultural Containers (e.g. bins, etc.)			
25. Tree holes			
26. Horse/livestock watering troughs			
27. Water under buildings			
28. Utility vaults			
29. Dredge Disposal Pond			
30. Wells/Water Storage Tanks/Pumps			
31. Water Main Leaks			
32. Other Natural Water Sources			
33. Other Commercial Sources			
34. Other			
35. Fresh Water Pond (Natural)			
36. Cess Pool			
Total	Product	Ounces (volume)	

Table A22. **Pesticide Application Data for Fall 2011 – NCMAD**

Application Sites:	5% Skeeter Abate - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	5% Skeeter Abate - Comments	Teknar HP-D - # Treatments	Total Amount Used4	Total Amount Type4	Total Amount Unit5	Teknar HP-D - Comments	Altosid Liquid SR5 - # Treatments	Total Amount Used11	Total Amount Type11	Total Amount Unit12	Altosid Liquid SR5 - Comments	Altosid Pellets - # Treatments	Total Amount Used15	Total Amount Type15	Total Amount Unit16
1. Tidal marsh																			
2. Fresh water marsh	5	1072	Product	Ounces (weight)															
2A. Reclaimed Marsh																			
3. Diked marsh																			
4. Seasonal wetland																			
4A. Seasonal Vineyard Water/Pothole																			
5. Natural seep																			
6. River margin																			
7. Creek																			
8. Seasonal creek pools																			
9. Channel (unlined)	4	82	Product	Ounces (weight)		2	208	Product	Ounces (volume)		1	52	Product	Ounces (volume)		1	4	Product	Ounces (weight)
10. Ditch																			
11. Vernal pool																			
12. Flooded/irrigated pasture	1	16	Product	Ounces (weight)															
13. Storm drain/catch basin	2	22	Product	Ounces (weight)															
14. Waste water pond	2	48	Product	Ounces (weight)															
14A. Waste Water Spray Field/Marsh																			
15. Winery waste pond																			
16. Stock pond																			
17. Irrigation pond/Vineyard Pond																			
18. Storm water detention basin																			
19. Sump	1	6	Product	Ounces (weight)												1	2	Product	Ounces (weight)
20. Septic tank																			
21. Ornamental water garden/fish pond																			
22. Swimming pool																			
23. Spa/hot tub																			
24. Man-made container (e.g. buckets, tires, cemetery urns, wading pools, wheel barrow, etc)	8	36	Product	Ounces (weight)															
24A. Agricultural Containers (e.g. bins, etc.)																			
25. Tree holes																			
26. Horse/livestock watering troughs																			
27. Water under buildings																			
28. Utility vaults																			
29. Dredge Disposal Pond																			
30. Wells/Water Storage Tanks/Pumps																			
31. Water Main Leaks	2	12	Product	Ounces (weight)												1	24	Product	Ounces (weight)
32. Other Natural Water Sources	4	38	Product	Ounces (weight)															
33. Other Commercial Sources																			
34. Other																			
Total	29	1332	Product	Ounces (weight)		2	208	Product	Ounces (volume)		1	52	Product	Ounces (volume)		3	30	Product	Ounces (weight)

Table A22.

Application Sites:	Altosid Pellets - Comments	VectoLex CG - # Treatments	Total Amount Used19	Total Amount Type19	Total Amount Unit20	VectoLex CG - Comments	VectoMax WSP - # Treatments	Total Amount Used21	Total Amount Type21	Total Amount Unit22	VectoMax WSP - Comments	Altosid Briquets 30-day - # Treatments	Total Amount Used23	Total Amount Type23	Total Amount Unit24	Altosid Briquets 30-day - Comments	Drione Insecticide - # Treatments	Total Amount Used35	Total Amount Type35
1. Tidal marsh																			
2. Fresh water marsh																			
2A. Reclaimed Marsh																			
3. Diked marsh																			
4. Seasonal wetland																			
4A. Seasonal Vineyard Water/Pothole																			
5. Natural seep																			
6. River margin																			
7. Creek																			
8. Seasonal creek pools																			
9. Channel (unlined)																			
10. Ditch																			
11. Vernal pool																			
12. Flooded/irrigated pasture																			
13. Storm drain/catch basin																			
14. Waste water pond																			
14A. Waste Water Spray Field/Marsh																			
15. Winery waste pond																			
16. Stock pond																			
17. Irrigation pond/Vineyard Pond																			
18. Storm water detention basin																			
19. Sump																			
20. Septic tank							2	14	Product	(specify in comments se	Each								
21. Ornamental water garden/fish pond																			
22. Swimming pool																			
23. Spa/hot tub																			
24. Man-made container (e.g. buckets, tires, cemetery urns, wading pools, wheel barrow, etc)		1	3	Product	Ounces (weight)		3	10	Product	(specify in comments se	Each	1	3	Product	(specify in comments se	Each			
24A. Agricultural Containers (e.g. bins, etc.)																			
25. Tree holes																			
26. Horse/livestock watering troughs																			
27. Water under buildings																			
28. Utility vaults							1	5	Product	(specify in comments se	Each								
29. Dredge Disposal Pond																			
30. Wells/Water Storage Tanks/Pumps																			
31. Water Main Leaks							1	11	Product	(specify in comments se	Each								
32. Other Natural Water Sources																			
33. Other Commercial Sources																			
34. Other																	54	112	Product
Total		1	3	Product	Ounces (weight)		7	40	Product	(specify in comments se	Each	1	3	Product	(specify in comments se	Each	54	112	Product

Table A22.

Application Sites:	Total Amount Unit36	Drione Insecticide - Comments	Contrac All-Weather Blox - # Treatments	Total Amount Used39	Total Amount Type39	Total Amount Unit40	Contrac All-Weather Blox - Comments	GB1111 Larv. Oil # Treatment	Total Amount Used	Total Amount Type2	Total Amount Unit	GB1111 Larv. Oil Comments
1. Tidal marsh												
2. Fresh water marsh												
2A. Reclaimed Marsh												
3. Diked marsh												
4. Seasonal wetland												
4A. Seasonal Vineyard Water/Pothole												
5. Natural seep												
6. River margin												
7. Creek												
8. Seasonal creek pools												
9. Channel (unlined)												
10. Ditch												
11. Vernal pool												
12. Flooded/irrigated pasture												
13. Storm drain/catch basin												
14. Waste water pond								5	75	Product	Ounces (volume)	
14A. Waste Water Spray Field/Marsh												
15. Winery waste pond								1	16	Product	Ounces (volume)	
16. Stock pond												
17. Irrigation pond/Vineyard Pond												
18. Storm water detention basin												
19. Sump								1	2	Product	Ounces (volume)	
20. Septic tank								2	18	Product	Ounces (volume)	
21. Ornamental water garden/fish pond												
22. Swimming pool												
23. Spa/hot tub												
24. Man-made container (e.g. buckets, tires, cemetery urns, wading pools, wheel barrow, etc)								2	6	Product	Ounces (volume)	
24A. Agricultural Containers (e.g. bins, etc.)												
25. Tree holes												
26. Horse/livestock watering troughs												
27. Water under buildings												
28. Utility vaults												
29. Dredge Disposal Pond												
30. Wells/Water Storage Tanks/Pumps												
31. Water Main Leaks												
32. Other Natural Water Sources												
33. Other Commercial Sources			2	20	Product	(specify in comments s	Each					
34. Other	Ounces (weight)		16	142	Product	(specify in comments s	Each					
Total	Ounces (weight)		18	162	Product	(specify in comments s	Each	11	117	Product	Ounces (volume)	

Table A23. **Pesticide Application Data for Winter 2012 – NCMAD**

Application Sites:	5% Skeeter Abate - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	5% Skeeter Abate - Comments	Teknar HP-D - # Treatments	Total Amount Used4	Total Amount Type4	Total Amount Unit5	Teknar HP-D - Comments	Altosid Liquid SR5 - # Treatments	Total Amount Used11	Total Amount Type11	Total Amount Unit12	Altosid Liquid SR5 - Comments	Altosid Pellets - # Treatments	Total Amount Used15	Total Amount Type15	Total Amount Unit16
1. Tidal marsh						2	176	Product	Ounces (volume)		2	44	Product	Ounces (volume)		1	352	Product	Ounces (weight)
2. Fresh water marsh	3	832	Product	Ounces (weight)		4	520	Product	Ounces (volume)		4	130	Product	Ounces (volume)		1	352	Product	Ounces (weight)
2A. Reclaimed Marsh	1	704	Product	Ounces (weight)												1	704	Product	Ounces (weight)
3. Diked marsh																			
4. Seasonal wetland	20	1332	Product	Ounces (weight)		4	240	Product	Ounces (volume)		3	40	Product	Ounces (volume)		16	1584	Product	Ounces (weight)
4A. Seasonal Vineyard Water/Pothole																			
5. Natural seep																			
6. River margin																			
7. Creek																			
8. Seasonal creek pools																			
9. Channel (unlined)	4	148	Product	Ounces (weight)		4	560	Product	Ounces (volume)		5	160	Product	Ounces (volume)		5	224	Product	Ounces (weight)
10. Ditch																			
11. Vernal pool																			
12. Flooded/irrigated pasture	1	16	Product	Ounces (weight)															
13. Storm drain/catch basin	1	3	Product	Ounces (weight)															
14. Waste water pond																			
14A. Waste Water Spray Field/Marsh						1	320	Product	Ounces (volume)		1	80	Product	Ounces (volume)		1	704	Product	Ounces (weight)
15. Winery waste pond																			
16. Stock pond																			
17. Irrigation pond/Vineyard Pond																			
18. Storm water detention basin						2	400	Product	Ounces (volume)		2	100	Product	Ounces (volume)		3	728	Product	Ounces (weight)
19. Sump	2	7	Product	Ounces (weight)															
20. Septic tank																			
21. Ornamental water garden/fish pond																			
22. Swimming pool																1	4	Product	Ounces (weight)
23. Spa/hot tub																			
24. Man-made container (e.g. buckets, tires, cemetery urns, wading pools, wheel barrow, etc)	11	91	Product	Ounces (weight)												1	3	Product	Ounces (weight)
24A. Agricultural Containers (e.g. bins, etc.)																			
25. Tree holes	1	16	Product	Ounces (weight)												1	16	Product	Ounces (weight)
26. Horse/livestock watering troughs																			
27. Water under buildings																			
28. Utility vaults																			
29. Dredge Disposal Ponds																			
30. Wells/Water Storage Tanks/Pumps																			
31. Water Main Leaks	1	160	Product	Ounces (weight)															
32. Other Natural Water Sources																			
33. Other Commercial Sources																			
34. Other																			
35. Fresh Water Pond (Natural)																1	352	Product	Ounces (weight)
36. Fish Pond/Water Garden																			
Total	45	3309	Product	Ounces (weight)		17	2216	Product	Ounces (volume)		17	554	Product	Ounces (volume)		32	5023	Product	Ounces (weight)

Table A23.

Application Sites:	Altosid Pellets - Comments	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type17	Total Amount Unit18	BVA-2 - Comments	VectoLex CG - # Treatments	Total Amount Used19	Total Amount Type19	Total Amount Unit20	VectoLex CG - Comments	VectoMax WSP - # Treatments	Total Amount Used21	Total Amount Type21	Total Amount Unit22	VectoMax WSP - Comments	Altosid Briquets 30-day - # Treatments	Total Amount Used23	Total Amount Type23
1. Tidal marsh																			
2. Fresh water marsh												1	14	Product	(specify in comments s	Each			
2A. Reclaimed Marsh																			
3. Diked marsh																			
4. Seasonal wetland		7	1084	Product	Ounces (volume)		1	8	Product	Ounces (weight)		9	122	Product	(specify in comments s	Each	5	93	Product
4A. Seasonal Vineyard Water/Pothole																			
5. Natural seep																			
6. River margin																			
7. Creek																			
8. Seasonal creek pools		1	384	Product	Ounces (volume)														
9. Channel (unlined)		3	928	Product	Ounces (volume)							2	28	Product	(specify in comments s	Each	2	10	Product
10. Ditch																			
11. Vernal pool																			
12. Flooded/irrigated pasture																			
13. Storm drain/catch basin		1	384	Product	Ounces (volume)							1	2	Product	(specify in comments s	Each			
14. Waste water pond																			
14A. Waste Water Spray Field/Marsh		2	2560	Product	Ounces (volume)							1	5	Product	(specify in comments s	Each			
15. Winery waste pond																			
16. Stock pond																			
17. Irrigation pond/Vineyard Pond																			
18. Storm water detention basin		1	256	Product	Ounces (volume)		1	32	Product	Ounces (weight)							1	15	Product
19. Sump																			
20. Septic tank												1	4	Product	(specify in comments s	Each			
21. Ornamental water garden/fish pond																			
22. Swimming pool																			
23. Spa/hot tub																			
24. Man-made container (e.g. buckets, tires, cemetery urns, wading pools, wheel barrow, etc)		6	12	Product	Ounces (volume)		1	4	Product	Ounces (weight)		7	86	Product	(specify in comments s	Each	5	82	Product
24A. Agricultural Containers (e.g. bins, etc.)																			
25. Tree holes																			
26. Horse/livestock watering troughs																			
27. Water under buildings																			
28. Utility vaults												2	20	Product	(specify in comments s	Each	1	10	Product
29. Dredge Disposal Ponds																			
30. Wells/Water Storage Tanks/Pumps																			
31. Water Main Leaks																			
32. Other Natural Water Sources																			
33. Other Commercial Sources																			
34. Other																			
35. Fresh Water Pond (Natural)																			
36. Fish Pond/Water Garden												1	4	Product	(specify in comments s	Each			
Total		21	5608	Product	Ounces (volume)		3	44	Product	Ounces (weight)		25	285	Product	(specify in comments s	Each	14	210	Product

Table A23.

Application Sites:	Total Amount Unit24	Altosid Briquets 30-day - Comments	Contrac All-Weather Blox - # Treatments	Total Amount Used39	Total Amount Type39	Total Amount Unit40	Contrac All-Weather Blox - Comments	GB1111 Larv. Oil # Treatments	Total Amount Used	Total Amount Type3	Total Amount Unit	GB1111 Larv. Oil Comments
1. Tidal marsh												
2. Fresh water marsh												
2A. Reclaimed Marsh												
3. Diked marsh												
4. Seasonal wetland	(specify in comments s	Each						4	640	Product	Ounces (volume)	
4A. Seasonal Vineyard Water/Pothole												
5. Natural seep												
6. River margin												
7. Creek												
8. Seasonal creek pools												
9. Channel (unlined)	(specify in comments s	Each						1	32	Product	Ounces (volume)	
10. Ditch												
11. Vernal pool												
12. Flooded/irrigated pasture												
13. Storm drain/catch basin												
14. Waste water pond												
14A. Waste Water Spray Field/Marsh								1	128	Product	Ounces (volume)	
15. Winery waste pond												
16. Stock pond												
17. Irrigation pond/Vineyard Pond												
18. Storm water detention basin	(specify in comments s	Each						3	768	Product	Ounces (volume)	
19. Sump												
20. Septic tank												
21. Ornamental water garden/fish pond												
22. Swimming pool												
23. Spa/hot tub												
24. Man-made container (e.g. buckets, tires, cemetery urns, wading pools, wheel barrow, etc)	(specify in comments s	Each						2	12	Product	Ounces (volume)	
24A. Agricultural Containers (e.g. bins, etc.)												
25. Tree holes												
26. Horse/livestock watering troughs												
27. Water under buildings												
28. Utility vaults	(specify in comments s	Each										
29. Dredge Disposal Ponds												
30. Wells/Water Storage Tanks/Pumps												
31. Water Main Leaks												
32. Other Natural Water Sources												
33. Other Commercial Sources			2	110	Product	(specify in comments s	Each					
34. Other			29	351	Product	(specify in comments s	Each					
35. Fresh Water Pond (Natural)												
36. Fish Pond/Water Garden												
Total	(specify in comments s	Each	31	461	Product	(specify in comments s	Each	11	1580	Product	Ounces (volume)	

Table A24. **Pesticide Application Data for Spring 2012 – NCMAD**

Application Sites:	5% Skeeter Abate - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	5% Skeeter Abate - Comments	Teknar HP-D - # Treatments	Total Amount Used4	Total Amount Type4	Total Amount Unit5	Teknar HP-D - Comments	Altosid Liquid SR5 - # Treatments	Total Amount Used11	Total Amount Type11	Total Amount Unit12	Altosid Liquid SR5 - Comments	Altosid Pellets - # Treatments	Total Amount Used15	Total Amount Type15	Total Amount Unit16
1. Tidal marsh	1	96	Product	Ounces (weight)		6	2480	Product	Ounces (volume)		5	320	Product	Ounces (volume)		1	1408	Product	Ounces (weight)
2. Fresh water marsh						7	2480	Product	Ounces (volume)		7	620	Product	Ounces (volume)		2	992	Product	Ounces (weight)
2A. Reclaimed Marsh											4	44	Product	Ounces (volume)					
3. Diked marsh	1	160	Product	Ounces (weight)															
4. Seasonal wetland/Rain Water	30	1657	Product	Ounces (weight)		23	1538	Product	Ounces (volume)		22	344	Product	Ounces (volume)		24	1660	Product	Ounces (weight)
4A. Seasonal Vineyard Water/Pothole						2	800	Product	Ounces (volume)							1	704	Product	Ounces (weight)
5. Natural seep	1	15	Product	Ounces (weight)															
6. River margin																			
7. Creek						1	32	Product	Ounces (volume)		1	8	Product	Ounces (volume)					
8. Seasonal creek pools																			
9. Channel (unlined)	14	487	Product	Ounces (weight)		22	1056	Product	Ounces (volume)		18	202	Product	Ounces (volume)		7	466	Product	Ounces (weight)
10. Ditch																			
11. Vernal pool																			
12. Flooded/irrigated pasture	1	64	Product	Ounces (weight)												1	32	Product	Ounces (weight)
13. Storm drain/catch basin	1	13	Product	Ounces (weight)		6	408	Product	Ounces (volume)		6	102	Product	Ounces (volume)		1	6	Product	Ounces (weight)
14. Waste water pond																			
14A. Waste Water Spray Field/Marsh						2	200	Product	Ounces (volume)		2	50	Product	Ounces (volume)					
15. Winery waste pond											5	188	Product	Ounces (volume)					
16. Stock pond																			
17. Irrigation pond/Vineyard Pond																			
18. Storm water detention basin						4	480	Product	Ounces (volume)		4	120	Product	Ounces (volume)		2	80	Product	Ounces (weight)
19. Sump																2	4	Product	Ounces (weight)
20. Septic tank	2	10	Product	Ounces (weight)															
21. Ornamental water garden/fish pond																			
22. Swimming pool	1	3	Product	Ounces (weight)															
23. Spa/hot tub																			
24. Man-made container (e.g. buckets, tires, cemetery urns, wading pools, wheel barrow, etc)	15	134	Product	Ounces (weight)												3	8	Product	Ounces (weight)
24A. Agricultural Containers (e.g. bins, etc)											1	40	Product	Ounces (volume)					
25. Tree holes																			
26. Horse/livestock watering troughs																			
27. Water under buildings																			
28. Utility vaults																			
29. Dredge Disposal Pond	1	160	Product	Ounces (weight)												1	160	Product	Ounces (weight)
30. Wells/Water Storage Tanks/Pumps																			
31. Water Main Leaks																			
32. Other Natural Water Sources											1	40	Product	Ounces (volume)		1	64	Product	Ounces (weight)
33. Other Commercial Sources																			
34. Other																			
Total	68	2799	Product	Ounces (weight)		73	9474	Product	Ounces (volume)		76	2078	Product	Ounces (volume)		46	5584	Product	Ounces (weight)

Table A24.

Application Sites:	Altosid Pellets - Comments	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type17	Total Amount Unit18	BVA-2 - Comments	VectoLex CG - # Treatments	Total Amount Used19	Total Amount Type19	Total Amount Unit20	VectoLex CG - Comments	VectoMax WSP - # Treatments	Total Amount Used21	Total Amount Type21	Total Amount Unit22	VectoMax WSP - Comments	Altosid Briquets 30-day - # Treatments	Total Amount Used23	Total Amount Type23
1. Tidal marsh																			
2. Fresh water marsh		2	1280	Product	Ounces (volume)														
2A. Reclaimed Marsh																			
3. Diked marsh																			
4. Seasonal wetland/Rain Water		24	2538	Product	Ounces (volume)		18	1092	Product	Ounces (weight)		11	204	Product	(specify in comments s	Each	4	114	Product
4A. Seasonal Vineyard Water/Pothole		2	2176	Product	Ounces (volume)		5	672	Product	Ounces (weight)									
5. Natural seep		3	520	Product	Ounces (volume)														
6. River margin																			
7. Creek												1	2	Product	(specify in comments s	Each			
8. Seasonal creek pools		1	2	Product	Ounces (volume)														
9. Channel (unlined)		3	1600	Product	Ounces (volume)		1	13	Product	Ounces (weight)		5	0	Product	(specify in comments s	Each	3	16	Product
10. Ditch																			
11. Vernal pool																			
12. Flooded/irrigated pasture																			
13. Storm drain/catch basin		3	386	Product	Ounces (volume)		2	14	Product	Ounces (weight)		31	1263	Product	(specify in comments s	Each	5	2246	Product
14. Waste water pond		1	256	Product	Ounces (volume)		1	64	Product	Ounces (weight)		1	12	Product	(specify in comments s	Each			
14A. Waste Water Spray Field/Marsh		1	256	Product	Ounces (volume)														
15. Winery waste pond																			
16. Stock pond																			
17. Irrigation pond/Vineyard Pond		1	6	Product	Ounces (volume)		2	320	Product	Ounces (weight)		1	18	Product	(specify in comments s	Each			
18. Storm water detention basin		2	640	Product	Ounces (volume)														
19. Sump		3	21	Product	Ounces (volume)							3	1	Product	(specify in comments s	Each	2	54	Product
20. Septic tank		2	12	Product	Ounces (volume)		1	4	Product	Ounces (weight)		1	5	Product	(specify in comments s	Each			
21. Ornamental water garden/fish pond																			
22. Swimming pool												1	8	Product	(specify in comments s	Each			
23. Spa/hot tub																			
24. Man-made container (e.g. buckets, tires, cemetery urns, wading pools, wheel barrow, etc)		16	107	Product	Ounces (volume)		6	75	Product	Ounces (weight)		30	249	Product	(specify in comments s	Each	14	138	Product
24A. Agricultural Containers (e.g. bins, etc)		1	32	Product	Ounces (volume)														
25. Tree holes												1	2	Product	(specify in comments s	Each			
26. Horse/livestock watering troughs												1	4	Product	(specify in comments s	Each			
27. Water under buildings																			
28. Utility vaults		1	128	Product	Ounces (volume)							3	46	Product	(specify in comments s	Each			
29. Dredge Disposal Pond																			
30. Wells/Water Storage Tanks/Pumps		1	6	Product	Ounces (volume)														
31. Water Main Leaks												1	10	Product	(specify in comments s	Each			
32. Other Natural Water Sources												1	48	Product	(specify in comments s	Each			
33. Other Commercial Sources																			
34. Other																			
Total		67	9966	Product	Ounces (volume)		36	2254	Product	Ounces (weight)		92	1872	Product	(specify in comments s	Each	28	2568	Product

Table A24.

Application Sites:	Total Amount Unit24	Altosid Briquets 30-day - Commments	MGK Pyrocide 7396 - # Treatments	Total Amount Used27	Total Amount Type27	Total Amount Unit28	MGK Pyrocide 7396 - Comments	Drione Insecticide - # Treatments	Total Amount Used35	Total Amount Type35	Total Amount Unit36	Drione Insecticide - Comments	Contrac All-Weather Blox - # Treatments	Total Amount Used39	Total Amount Type39	Total Amount Unit40	Contrac All-Weather Blox -Comments
1. Tidal marsh																	
2. Fresh water marsh																	
2A. Reclaimed Marsh																	
3. Diked marsh																	
4. Seasonal wetland/Rain Water	(specify in comments s	Each															
4A. Seasonal Vineyard Water/Pothole																	
5. Natural seep																	
6. River margin																	
7. Creek																	
8. Seasonal creek pools																	
9. Channel (unlined)	(specify in comments s	Each															
10. Ditch																	
11. Vernal pool																	
12. Flooded/irrigated pasture																	
13. Storm drain/catch basin	(specify in comments s	Each															
14. Waste water pond																	
14A. Waste Water Spray Field/Marsh																	
15. Winery waste pond																	
16. Stock pond																	
17. Irrigation pond/Vineyard Pond																	
18. Storm water detention basin																	
19. Sump	(specify in comments s	Each															
20. Septic tank																	
21. Ornamental water garden/fish pond																	
22. Swimming pool																	
23. Spa/hot tub																	
24. Man-made container (e.g. buckets, tires, cemetery urns, wading pools, wheel barrow, etc)	(specify in comments s	Each															
24A. Agricultural Containers (e.g. bins, etc)																	
25. Tree holes			132	7879	Product	Ounces (volume)											
26. Horse/livestock watering troughs																	
27. Water under buildings																	
28. Utility vaults																	
29. Dredge Disposal Pond																	
30. Wells/Water Storage Tanks/Pumps																	
31. Water Main Leaks																	
32. Other Natural Water Sources																	
33. Other Commercial Sources																	
34. Other								12	24	Product	Ounces (weight)		21	295	Product	(specify in comments s	Each
Total	(specify in comments s	Each	132	7879	Product	Ounces (volume)		12	24	Product	Ounces (weight)		21	295	Product	(specify in comments s	Each

Table A25. Pesticide Product Key – NCMAD

Product	AI	Vector
5% Skeeter Abate	Temephos	Mosquito
Altosid Briquets 30-day	Methoprene	Mosquito
Altosid Liquid SR5	Methoprene	Mosquito
Altosid Pellets	Methoprene	Mosquito
BVA-2	Petroleum Distillate	Mosquito
Contrac All-Weather Blox	Bromadiolone	Rat
Drione Insecticide	Pyrethrin and Piperonyl Butroxide and Amorphous Silica Gel	Yellow Jacket / Wasp
MGK Pyrocide 7396	Pyrethrins and Piperonyl Butoxide	Mosquito
Permanone	Permethrin and Piperonyl Butoxide	Mosquito
Pyrenone 25-5	Pyrethrins and Piperonyl Butoxide	Mosquito
Teknar HP-D	Bacillus Thuringiensis Israelensis	Mosquito
VectoLex CG	Bacillus Sphaericus	Mosquito
VectoMax WSP	Bacillus Sphaericus and Bacillus Thuringiensis Israelensis	Mosquito
Wasp Freeze	Phenothrin and Trans Allethrin	Yellow Jacket / Wasp

Table A26. Pesticide Application Data for Summer 2011 – NSVMAD

Application Sites:	Agnique MMF - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Agnique MMF Comments	VectoBac G - # Treatments	Total Amount Used2	Total Amount Type3	Total Amount Unit3	VectoBac G Comments	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit18	BVA-2 Comments
Storm Drains			Product	Ounces (volume)				Product	Pounds		500	20	Product	Gallons	
Catch Basins			Product	Ounces (volume)				Product	Pounds		500	20	Product	Gallons	
Troughs			Product	Ounces (volume)				Product	Pounds						
Water Features	3	6	Product	Ounces (volume)	Swimming pools			Product	Pounds						
Containers			Product	Ounces (volume)				Product	Pounds						
Standing / Flood Water			Product	Ounces (volume)		3	800	Product	Pounds						
Pastures			Product	Ounces (volume)				Product	Pounds						
Salt Marsh			Product	Ounces (volume)		5	2000	Product	Pounds						
Estuaries			Product	Ounces (volume)		5	1000	Product	Pounds						
Tidal / Woodland Pools			Product	Ounces (volume)		5	1000	Product	Pounds						
Wastewater			Product	Ounces (volume)		3	300	Product	Pounds		1	50	Product	Gallons	
Ditches			Product	Ounces (volume)		2	300	Product	Pounds		1	50	Product	Gallons	
Sewer / Dairy lagoons			Product	Ounces (volume)				Product	Pounds						
Retention / Detention Ponds			Product	Ounces (volume)				Product	Pounds		1	50	Product	Gallons	
Rural / Urban Residences			Product	Ounces (volume)				Product	Pounds						
Totals	3	6	Product	Ounces (volume)		23	5400	Product	Pounds		1003	190	Product	Gallons	

Table A26.

Application Sites:	VectoLex CG - # Treatments	Total Amount Used19	Total Amount Type20	Total Amount Unit20	VectoLex CG Comments	Natular G30 - # Treatments	Total Amount Used1924	Total Amount Type2025	Total Amount Unit2026	Natular G30 Comments
Storm Drains			Product	Pounds						
Catch Basins			Product	Pounds						
Troughs			Product	Pounds						
Water Features			Product	Pounds						
Containers			Product	Pounds						
Standing / Flood Water			Product	Pounds						
Pastures			Product	Pounds						
Salt Marsh	1	120	Product	Pounds		1	300	Product	Pounds	works well in colder temps
Estuaries			Product	Pounds						
Tidal / Woodland Pools			Product	Pounds						
Wastewater	1	80	Product	Pounds						
Ditches	1	80	Product	Pounds						
Sewer / Dairy lagoons			Product	Pounds						
Retention / Detention Ponds			Product	Pounds						
Rural / Urban Residences			Product	Pounds						
Totals	3	280	Product	Pounds		1	300	Product	Pounds	

Table A27. Pesticide Application Data for Fall 2011 – NSVMAD

Application Sites:	Agnique MMF - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Agnique MMF Comments	VectoBac G - # Treatments	Total Amount Used2	Total Amount Type3	Total Amount Unit3	VectoBac G Comments	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit18	BVA-2 Comments
Storm Drains															
Catch Basins															
Troughs															
Water Features	1	1	Product	Ounces (weight)	swimming pool										
Containers															
Standing / Flood Water															
Pastures															
Salt Marsh															
Estuaries															
Tidal / Woodland Pools															
Wastewater						1	40	Product	Pounds		2	10	Product	Gallons	
Ditches											2	10	Product	Gallons	
Sewer / Dairy lagoons											2	10	Product	Gallons	
Retention / Detention Ponds											1	20	Product	Gallons	
Rural / Urban Residences															
Totals	1	1	Product	Ounces (weight)		1	40	Product	Pounds		7	50	Product	Gallons	

Table A27.

Application Sites:	Altosid XR-G (granules)-# Treatments	Total Amount Used39	Total Amount Type40	Total Amount Unit40	Altosid XR-G (granules) Blox Comments	Kontrol 4-4 - # Treatments	Total Amount Used1315	Total Amount Type1416	Total Amount Unit1417	Kontrol 4-4 Comments
Storm Drains	1	2	Product	Ounces (weight)						
Catch Basins										
Troughs										
Water Features										
Containers										
Standing / Flood Water										
Pastures										
Salt Marsh										
Estuaries										
Tidal / Woodland Pools										
Wastewater										
Ditches										
Sewer / Dairy lagoons										
Retention / Detention Ponds										
Rural / Urban Residences						1	78	Product	Ounces (weight)	
Totals	1	2	Product	Ounces (weight)		1	78	Product	Ounces (weight)	

Table A28. Pesticide Application Data for Winter 2012 – NSVMAD

Application Sites:	Agnique MMF - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Agnique MMF Comments	VectoBac G - # Treatments	Total Amount Used2	Total Amount Type3	Total Amount Unit3	VectoBac G Comments	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit18	BVA-2 Comments
Storm Drains											500	20	Product	Gallons	
Catch Basins											500	20	Product	Gallons	
Troughs															
Water Features															
Containers															
Standing / Flood Water															
Pastures															
Salt Marsh						2	300	Product	Pounds						
Estuaries						1	40	Product	Pounds						
Tidal / Woodland Pools															
Wastewater											1	10	Product	Gallons	
Ditches															
Sewer / Dairy lagoons															
Retention / Detention Ponds		8													
Rural / Urban Residences	9														
Totals	9	8		0		3	340	Product	Pounds		1001	50			

Table A28.

Application Sites:	Natular 2EC - # Treatments	Total Amount Used1721	Total Amount Type1822	Total Amount Unit1823	Natular 2EC Comments	Natular G30 - # Treatments	Total Amount Used1924	Total Amount Type2025	Total Amount Unit2026	Natular G30 Comments
Storm Drains										
Catch Basins										
Troughs										
Water Features										
Containers										
Standing / Flood Water										
Pastures										
Salt Marsh	2	3	Active Ingredient	Gallons	mixed @ 10oz/gal	1	40	Product	Pounds	
Estuaries	3	5	Active Ingredient	Gallons	mixed @ 10oz/gal	5	1000	Product	Pounds	
Tidal / Woodland Pools	2	3	Active Ingredient	Gallons	mixed @ 10oz/gal	3	500	Product	Pounds	
Wastewater										
Ditches										
Sewer / Dairy lagoons										
Retention / Detention Ponds										
Rural / Urban Residences										
Totals	7	11	Active Ingredient	Gallons	mixed @ 10oz/gal	9	1540	Product	Pounds	

Table A29. Pesticide Application Data for Spring 2012 – NSVMAD

Application Sites:	VectoBac G - # Treatments	Total Amount Used2	Total Amount Type3	Total Amount Unit3	VectoBac G Comments	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit18	BVA-2 Comments	Teknar HP-D - # Treatments	Total Amount Used27	Total Amount Type28	Total Amount Unit28	Teknar HP-D Comments
Storm Drains						1500	50	Product	Gallons						
Catch Basins						1500	50	Product	Gallons						
Troughs															
Water Features															
Containers															
Standing / Flood Water						5	35	Product	Gallons		5	3	Active Ingredient	Gallons	16 oz / gallon water
Pastures															
Salt Marsh	2	120	Product			5	40	Product	Gallons		3	10	Active Ingredient	Gallons	16 oz / gallon water
Estuaries	2	120	Product			5	50	Product	Gallons		3	10	Active Ingredient	Gallons	16 oz / gallon water
Tidal / Woodland Pools	2	120	Product			5	50	Product	Gallons						
Wastewater															
Ditches											5	3	Active Ingredient	Gallons	16 oz / gallon water
Sewer / Dairy lagoons											5	3	Active Ingredient	Gallons	16 oz / gallon water
Retention / Detention Ponds	2	40	Product								5	3	Active Ingredient	Gallons	16 oz / gallon water
Rural / Urban Residences															
Totals	8	400	Product	0		3020	275	Product	Gallons		26	32	Active Ingredient	Gallons	16 oz / gallon water

Table A29.

Application Sites:	FourStar 45 Bti - # Treatments	Total Amount Used35	Total Amount Type36	Total Amount Unit36	FourStar 45 Bti Comments	Natular G30 - # Treatments	Total Amount Used1924	Total Amount Type2025	Total Amount Unit2026	Natular G30 Comments
Storm Drains										
Catch Basins										
Troughs										
Water Features										
Containers										
Standing / Flood Water						3	250	Product	Pounds	
Pastures										
Salt Marsh	10	5000				3	250	Product	Pounds	
Estuaries	10	5000				3	250	Product	Pounds	
Tidal / Woodland Pools	5	3000				3	250	Product	Pounds	
Wastewater	10	1000				5	100	Product	Pounds	
Ditches										
Sewer / Dairy lagoons	5	1000								
Retention / Detention Ponds										
Rural / Urban Residences										
Totals	40	15000				17	1100	Product	Pounds	

Table A30. Pesticide Product Key – NSVMAD

Product	AI	Vector
VectoLex CG Biologic	Bacillus Sphaericus	Mosquito
FourStar 45 Bti	Bacillus Sphaericus and Bacillus Thuringiensis Israelensis	Mosquito
Teknar HP-D	Bacillus Thuringiensis Israelensis	Mosquito
VectoBac G	Bacillus Thuringiensis Israelensis	Mosquito
Agnique MMF	Biodegradable Alcohol Ethoxylated Surfactant	Mosquito
Altosid XR-G (granules)	Methoprene	Mosquito
Kontrol 4-4	Permethrin and Piperonyl Butoxide	Mosquito
BVA 2	Petroleum Distillate	Mosquito
Natular G30	Spinosad	Mosquito
Natular 2EC	Spinosad	Mosquito

Table A31. Pesticide Application Data for Summer 2011 – SCCVCD

Application Sites:	Agnique MMF-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Agnique MMF Comments	AGNIQUE MMF G-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	AGNIQUE MMF G Comments	Altosid Briquets 30-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Altosid Briquets 30 Comments
	7	0.03998	Product	Gallons		1	0.6916	Product	Pounds		2	0.045	Product	Pounds	
Bird Bath			Product	Gallons				Product	Pounds		1	0.03	Product	Pounds	
Catch Basin	5	0.008035	Product	Gallons				Product	Pounds				Product	Pounds	
Cemetery vases	4	0.004591	Product	Gallons				Product	Pounds				Product	Pounds	
Channel	2	0.092961	Product	Gallons		1	0.8398	Product	Pounds				Product	Pounds	
Clean Pool	3	0.022507	Product	Gallons				Product	Pounds				Product	Pounds	
Commercial			Product	Gallons				Product	Pounds				Product	Pounds	
Container			Product	Gallons				Product	Pounds				Product	Pounds	
Creek	16	0.914632	Product	Gallons		15	33.341	Product	Pounds		1	0.33	Product	Pounds	
Curbs	51	0.850476	Product	Gallons		10	43.918875	Product	Pounds				Product	Pounds	
Dairy Drain	1	0.001148	Product	Gallons				Product	Pounds				Product	Pounds	
Diked Marsh			Product	Gallons				Product	Pounds				Product	Pounds	
Drain			Product	Gallons				Product	Pounds				Product	Pounds	
Fish Pond			Product	Gallons				Product	Pounds				Product	Pounds	
Flooded Area	2	0.002525	Product	Gallons				Product	Pounds				Product	Pounds	
FW Marsh			Product	Gallons		1	0.1	Product	Pounds				Product	Pounds	
Impound			Product	Gallons		1	0.4199	Product	Pounds				Product	Pounds	
Lake			Product	Gallons				Product	Pounds				Product	Pounds	
Lift Station			Product	Gallons				Product	Pounds				Product	Pounds	
Neglected Pool	84	0.431675	Product	Gallons		9	0.8022	Product	Pounds				Product	Pounds	
Ornamental Pond	5	0.01033	Product	Gallons		1	0.07	Product	Pounds				Product	Pounds	
Park			Product	Gallons				Product	Pounds				Product	Pounds	
Parking garage			Product	Gallons				Product	Pounds				Product	Pounds	
Pond	5	0.401396	Product	Gallons		3	3.9026	Product	Pounds				Product	Pounds	
Residential	2	0.014357	Product	Gallons				Product	Pounds				Product	Pounds	
Salt Marsh			Product	Gallons				Product	Pounds				Product	Pounds	
Seepage			Product	Gallons				Product	Pounds				Product	Pounds	
Sewer Pond	66	0.422688	Product	Gallons		20	4.3892	Product	Pounds				Product	Pounds	
Tires			Product	Gallons				Product	Pounds				Product	Pounds	
Utility Vault			Product	Gallons				Product	Pounds				Product	Pounds	
Watering Trough	1	0.00023	Product	Gallons				Product	Pounds				Product	Pounds	
Totals	254	3.217531	Product	Gallons		62	88.475175	Product	Pounds		4	0.405	Product	Pounds	

Table A31.

Application Sites:	Altosid XR Briquets-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Altosid XR Briquets Comments	Altosid XR-G-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Altosid XR-G Comments	BVA 2 Mosquito Larvi-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	BVA 2 Mosquito Larvi Comments
			Product	Pounds				Product	Pounds				Product	Gallons	
Bird Bath			Product	Pounds				Product	Pounds		1	0.00825	Product	Gallons	
Catch Basin	1	1.2075	Product	Pounds				Product	Pounds		42	0.34625	Product	Gallons	
Cemetery vases	2	1.127	Product	Pounds				Product	Pounds		7	0.681875	Product	Gallons	
Channel	1	0.0805	Product	Pounds				Product	Pounds		3	0.018375	Product	Gallons	
Clean Pool			Product	Pounds				Product	Pounds		7	0.099609	Product	Gallons	
Commercial			Product	Pounds				Product	Pounds		1	0.0055	Product	Gallons	
Container			Product	Pounds				Product	Pounds		1	0.003906	Product	Gallons	
Creek	6	1.932	Product	Pounds		5	16.138	Product	Pounds		56	4.28474	Product	Gallons	
Curbs	10	2.9785	Product	Pounds		1	0.046	Product	Pounds		150	2.041118	Product	Gallons	
Dairy Drain			Product	Pounds				Product	Pounds				Product	Gallons	
Diked Marsh			Product	Pounds				Product	Pounds				Product	Gallons	
Drain			Product	Pounds				Product	Pounds		1	0.003906	Product	Gallons	
Fish Pond			Product	Pounds				Product	Pounds				Product	Gallons	
Flooded Area			Product	Pounds				Product	Pounds		10	0.476295	Product	Gallons	
FW Marsh			Product	Pounds				Product	Pounds				Product	Gallons	
Impound			Product	Pounds				Product	Pounds		4	0.111563	Product	Gallons	
Lake			Product	Pounds				Product	Pounds				Product	Gallons	
Lift Station			Product	Pounds				Product	Pounds				Product	Gallons	
Neglected Pool			Product	Pounds				Product	Pounds		31	0.170385	Product	Gallons	
Ornamental Pond			Product	Pounds				Product	Pounds				Product	Gallons	
Park			Product	Pounds				Product	Pounds				Product	Gallons	
Parking garage			Product	Pounds				Product	Pounds				Product	Gallons	
Pond			Product	Pounds		1	0.15	Product	Pounds		4	0.889188	Product	Gallons	
Residential			Product	Pounds				Product	Pounds		3	0.041313	Product	Gallons	
Salt Marsh			Product	Pounds				Product	Pounds		1	0.020625	Product	Gallons	
Seepage			Product	Pounds				Product	Pounds				Product	Gallons	
Sewer Pond			Product	Pounds				Product	Pounds		31	0.469939	Product	Gallons	
Tires			Product	Pounds				Product	Pounds				Product	Gallons	
Utility Vault			Product	Pounds				Product	Pounds		4	0.070313	Product	Gallons	
Watering Trough			Product	Pounds				Product	Pounds				Product	Gallons	
Totals	20	7.3255	Product	Pounds		7	16.334	Product	Pounds		357	9.74315	Product	Gallons	

Table A31.

Application Sites:	Drione Insecticide-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Drione Insecticide Comments	EcoExempt IC2-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	EcoExempt IC2 Comments	Fourstar 180 briq-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Fourstar 180 briq Comments
			Product	Pounds				Product	Gallons		1	0.125	Product	Pounds	
Bird Bath			Product	Pounds				Product	Gallons		1	0.0625	Product	Pounds	
Catch Basin			Product	Pounds				Product	Gallons		2	0.4375	Product	Pounds	
Cemetery vases			Product	Pounds				Product	Gallons				Product	Pounds	
Channel			Product	Pounds				Product	Gallons		3	0.5625	Product	Pounds	
Clean Pool			Product	Pounds				Product	Gallons		3	1.0625	Product	Pounds	
Commercial			Product	Pounds				Product	Gallons				Product	Pounds	
Container			Product	Pounds				Product	Gallons		2	0.875	Product	Pounds	
Creek			Product	Pounds				Product	Gallons		19	5.3125	Product	Pounds	
Curbs			Product	Pounds				Product	Gallons		5	0.8125	Product	Pounds	
Dairy Drain			Product	Pounds				Product	Gallons				Product	Pounds	
Diked Marsh			Product	Pounds				Product	Gallons				Product	Pounds	
Drain			Product	Pounds				Product	Gallons				Product	Pounds	
Fish Pond			Product	Pounds				Product	Gallons				Product	Pounds	
Flooded Area			Product	Pounds				Product	Gallons		2	0.1875	Product	Pounds	
FW Marsh			Product	Pounds				Product	Gallons				Product	Pounds	
Impound			Product	Pounds				Product	Gallons				Product	Pounds	
Lake			Product	Pounds				Product	Gallons				Product	Pounds	
Lift Station			Product	Pounds				Product	Gallons		1	0.125	Product	Pounds	
Neglected Pool			Product	Pounds				Product	Gallons		64	8.5625	Product	Pounds	
Ornamental Pond			Product	Pounds				Product	Gallons				Product	Pounds	
Park	2	0.04375	Product	Pounds				Product	Gallons				Product	Pounds	
Parking garage	1	0.0125	Product	Pounds				Product	Gallons				Product	Pounds	
Pond			Product	Pounds				Product	Gallons		1	0.125	Product	Pounds	
Residential			Product	Pounds				Product	Gallons		1	0.0625	Product	Pounds	
Salt Marsh			Product	Pounds				Product	Gallons				Product	Pounds	
Seepage			Product	Pounds				Product	Gallons				Product	Pounds	
Sewer Pond			Product	Pounds		4	0.070314	Product	Gallons		16	9.5625	Product	Pounds	
Tires			Product	Pounds				Product	Gallons		1	0.25	Product	Pounds	
Utility Vault			Product	Pounds				Product	Gallons				Product	Pounds	
Watering Trough			Product	Pounds				Product	Gallons				Product	Pounds	
Totals	3	0.05625	Product	Pounds		4	0.070314	Product	Gallons		122	28.125	Product	Pounds	

Table A31.

Application Sites:	Fourstar 45 briq-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Fourstar 45 briq Comments	Fourstar 90 briq-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Fourstar 90 briq Comments	Golden Bear 1111 Oil-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Golden Bear 1111 Oil Comments
			Product	Pounds				Product	Pounds				Product	Gallons	
Bird Bath			Product	Pounds				Product	Pounds				Product	Gallons	
Catch Basin			Product	Pounds				Product	Pounds				Product	Gallons	
Cemetery vases	2	0.210938	Product	Pounds				Product	Pounds				Product	Gallons	
Channel	1	0.28125	Product	Pounds				Product	Pounds				Product	Gallons	
Clean Pool			Product	Pounds				Product	Pounds				Product	Gallons	
Commercial			Product	Pounds				Product	Pounds				Product	Gallons	
Container			Product	Pounds				Product	Pounds		1	0.011719	Product	Gallons	
Creek	23	2.828127	Product	Pounds		4	1.375	Product	Pounds				Product	Gallons	
Curbs	2	0.03125	Product	Pounds				Product	Pounds		22	0.0825	Product	Gallons	
Dairy Drain			Product	Pounds				Product	Pounds				Product	Gallons	
Diked Marsh			Product	Pounds				Product	Pounds				Product	Gallons	
Drain			Product	Pounds				Product	Pounds				Product	Gallons	
Fish Pond			Product	Pounds				Product	Pounds				Product	Gallons	
Flooded Area			Product	Pounds				Product	Pounds		1	0.25	Product	Gallons	
FW Marsh			Product	Pounds				Product	Pounds				Product	Gallons	
Impound			Product	Pounds				Product	Pounds				Product	Gallons	
Lake	1	0.15625	Product	Pounds				Product	Pounds				Product	Gallons	
Lift Station			Product	Pounds				Product	Pounds				Product	Gallons	
Neglected Pool	3	0.019532	Product	Pounds		7	0.289063	Product	Pounds		5	0.154219	Product	Gallons	
Ornamental Pond	1	0.015625	Product	Pounds				Product	Pounds				Product	Gallons	
Park			Product	Pounds				Product	Pounds				Product	Gallons	
Parking garage			Product	Pounds				Product	Pounds				Product	Gallons	
Pond	1	0.0625	Product	Pounds				Product	Pounds				Product	Gallons	
Residential			Product	Pounds		2	0.09375	Product	Pounds				Product	Gallons	
Salt Marsh			Product	Pounds				Product	Pounds				Product	Gallons	
Seepage			Product	Pounds				Product	Pounds				Product	Gallons	
Sewer Pond			Product	Pounds				Product	Pounds				Product	Gallons	
Tires			Product	Pounds				Product	Pounds				Product	Gallons	
Utility Vault			Product	Pounds				Product	Pounds				Product	Gallons	
Watering Trough			Product	Pounds				Product	Pounds				Product	Gallons	
Totals	34	3.605472	Product	Pounds		13	1.757813	Product	Pounds		29	0.498438	Product	Gallons	

Table A31.

Application Sites:	Pyrenone 25-5-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Pyrenone 25-5 Comments	Vectobac 12AS-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Vectobac 12AS Comments	Vectobac G-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Vectobac G Comments
	13	77.58	Product	Gallons		1	0.000287	Product	Gallons		1	0.23	Product	Pounds	
Bird Bath			Product	Gallons				Product	Gallons				Product	Pounds	
Catch Basin			Product	Gallons				Product	Gallons		4	0.207	Product	Pounds	
Cemetery vases			Product	Gallons				Product	Gallons		4	0.92	Product	Pounds	
Channel			Product	Gallons		3	0.252294	Product	Gallons		16	34.548	Product	Pounds	
Clean Pool			Product	Gallons		4	0.051122	Product	Gallons				Product	Pounds	
Commercial	1	7.5	Product	Gallons		2	2.138189	Product	Gallons				Product	Pounds	
Container			Product	Gallons		1	0.000313	Product	Gallons		2	1.175	Product	Pounds	
Creek			Product	Gallons		61	3.602547	Product	Gallons		172	382.6285	Product	Pounds	
Curbs			Product	Gallons		11	2.929331	Product	Gallons		14	21.311313	Product	Pounds	
Dairy Drain			Product	Gallons				Product	Gallons		4	0.115	Product	Pounds	
Diked Marsh			Product	Gallons				Product	Gallons		1	25	Product	Pounds	
Drain			Product	Gallons				Product	Gallons				Product	Pounds	
Fish Pond			Product	Gallons		1	0.00172	Product	Gallons				Product	Pounds	
Flooded Area			Product	Gallons		5	0.205854	Product	Gallons		7	11.132	Product	Pounds	
FW Marsh			Product	Gallons				Product	Gallons		3	41	Product	Pounds	
Impound			Product	Gallons				Product	Gallons		2	0.5405	Product	Pounds	
Lake			Product	Gallons		1	0.019784	Product	Gallons				Product	Pounds	
Lift Station			Product	Gallons		3	0.026092	Product	Gallons				Product	Pounds	
Neglected Pool			Product	Gallons		15	1.103133	Product	Gallons		4	1.555	Product	Pounds	
Ornamental Pond			Product	Gallons		2	0.001798	Product	Gallons		2	0.09	Product	Pounds	
Park			Product	Gallons				Product	Gallons				Product	Pounds	
Parking garage			Product	Gallons				Product	Gallons				Product	Pounds	
Pond			Product	Gallons		7	0.237349	Product	Gallons		7	53.826	Product	Pounds	
Residential	4	19.8	Product	Gallons		1	0.00172	Product	Gallons		1	0.138	Product	Pounds	
Salt Marsh			Product	Gallons		4	11	Product	Gallons		16	104.203	Product	Pounds	
Seepage			Product	Gallons				Product	Gallons		1	0.23	Product	Pounds	
Sewer Pond			Product	Gallons		18	0.021757	Product	Gallons		15	11.408	Product	Pounds	
Tires			Product	Gallons				Product	Gallons				Product	Pounds	
Utility Vault			Product	Gallons				Product	Gallons				Product	Pounds	
Watering Trough			Product	Gallons				Product	Gallons				Product	Pounds	
Totals	18	104.88	Product	Gallons		140	21.59329	Product	Gallons		276	690.257313	Product	Pounds	

Table A31.

Application Sites:	Vectolex CG-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Vectolex CG Comments	Vectolex WSP-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Vectolex WSP Comments	Vectomax CG-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Vectomax CG Comments
	1	0.23	Product	Pounds				Product	Pounds				Product	Pounds	
Bird Bath			Product	Pounds				Product	Pounds				Product	Pounds	
Catch Basin			Product	Pounds				Product	Pounds				Product	Pounds	
Cemetery vases			Product	Pounds				Product	Pounds				Product	Pounds	
Channel	2	8.5	Product	Pounds				Product	Pounds				Product	Pounds	
Clean Pool			Product	Pounds				Product	Pounds				Product	Pounds	
Commercial			Product	Pounds				Product	Pounds				Product	Pounds	
Container			Product	Pounds				Product	Pounds				Product	Pounds	
Creek	86	116.5627	Product	Pounds				Product	Pounds				Product	Pounds	
Curbs	2	0.0345	Product	Pounds				Product	Pounds				Product	Pounds	
Dairy Drain			Product	Pounds				Product	Pounds				Product	Pounds	
Diked Marsh			Product	Pounds				Product	Pounds				Product	Pounds	
Drain			Product	Pounds				Product	Pounds				Product	Pounds	
Fish Pond			Product	Pounds				Product	Pounds				Product	Pounds	
Flooded Area	2	3.1004	Product	Pounds		1	0.5	Product	Pounds				Product	Pounds	
FW Marsh			Product	Pounds				Product	Pounds				Product	Pounds	
Impound	1	0.0115	Product	Pounds				Product	Pounds				Product	Pounds	
Lake			Product	Pounds				Product	Pounds				Product	Pounds	
Lift Station			Product	Pounds				Product	Pounds				Product	Pounds	
Neglected Pool	9	1.886	Product	Pounds		1	0.12	Product	Pounds		1	0.09	Product	Pounds	
Ornamental Pond	2	0.046	Product	Pounds				Product	Pounds				Product	Pounds	
Park			Product	Pounds				Product	Pounds				Product	Pounds	
Parking garage			Product	Pounds				Product	Pounds				Product	Pounds	
Pond	1	0.529	Product	Pounds				Product	Pounds				Product	Pounds	
Residential			Product	Pounds				Product	Pounds				Product	Pounds	
Salt Marsh			Product	Pounds				Product	Pounds				Product	Pounds	
Seepage	1	10	Product	Pounds				Product	Pounds				Product	Pounds	
Sewer Pond	2	0.046	Product	Pounds				Product	Pounds				Product	Pounds	
Tires			Product	Pounds				Product	Pounds				Product	Pounds	
Utility Vault			Product	Pounds				Product	Pounds				Product	Pounds	
Watering Trough			Product	Pounds				Product	Pounds				Product	Pounds	
Totals	109	140.9461	Product	Pounds		2	0.62	Product	Pounds		1	0.09	Product	Pounds	

Table A32. Pesticide Application Data for Fall 2011 – SCCVCD

Application Sites:	Agnique MMF-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Agnique MMF Comments	AGNIQUE MMF G-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	AGNIQUE MMF G Comments	Altosid Briquets 30-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Altosid Briquets 30 Comments
	1	0.009766	Product	Gallons				Product	Pounds				Product	Pounds	
Catch Basin	1	0.002295	Product	Gallons				Product	Pounds				Product	Pounds	
Cemetery vases	1	0.001148	Product	Gallons				Product	Pounds				Product	Pounds	
Channel			Product	Gallons				Product	Pounds				Product	Pounds	
Clean Pool			Product	Gallons				Product	Pounds				Product	Pounds	
Commercial			Product	Gallons				Product	Pounds				Product	Pounds	
Container	1	0.004591	Product	Gallons				Product	Pounds				Product	Pounds	
Creek	7	0.209313	Product	Gallons		4	1.2817	Product	Pounds		3	0.165	Product	Pounds	
Curbs	4	0.17554	Product	Gallons		2	3.1996	Product	Pounds		1	0.045	Product	Pounds	
Dairy Drain			Product	Gallons				Product	Pounds				Product	Pounds	
Diked Marsh			Product	Gallons				Product	Pounds				Product	Pounds	
Drain			Product	Gallons		1	0.0247	Product	Pounds				Product	Pounds	
Duck Pond			Product	Gallons				Product	Pounds				Product	Pounds	
Flooded Area	3	0.079189	Product	Gallons		2	0.4486	Product	Pounds				Product	Pounds	
FW Marsh			Product	Gallons		1	0.1976	Product	Pounds				Product	Pounds	
Impound			Product	Gallons				Product	Pounds				Product	Pounds	
Lake			Product	Gallons				Product	Pounds				Product	Pounds	
Lift Station			Product	Gallons				Product	Pounds				Product	Pounds	
Neglected Pool	3	0.025686	Product	Gallons		1	0.09	Product	Pounds				Product	Pounds	
Ornamental Pond	1	0.002289	Product	Gallons				Product	Pounds				Product	Pounds	
Pond	1	0.001148	Product	Gallons		1	5.928	Product	Pounds				Product	Pounds	
Residential	1	0.001148	Product	Gallons				Product	Pounds				Product	Pounds	
Salt Marsh			Product	Gallons				Product	Pounds				Product	Pounds	
Sewer Pond	7	0.018227	Product	Gallons		1	1.1856	Product	Pounds				Product	Pounds	
Tires	1	0.000156	Product	Gallons				Product	Pounds				Product	Pounds	
Treehole			Product	Gallons				Product	Pounds				Product	Pounds	
Utility Vault			Product	Gallons				Product	Pounds				Product	Pounds	
Watering Trough			Product	Gallons				Product	Pounds				Product	Pounds	
Totals	32	0.530496	Product	Gallons		13	12.3558	Product	Pounds		4	0.21	Product	Pounds	

Table A32.

Application Sites:	Altosid Pellets-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Altosid Pellets Comments	Altosid XR Briquets-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Altosid XR Briquets Comments	Altosid XR-G-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Altosid XR-G Comments
			Product	Pounds				Product	Pounds				Product	Pounds	
Catch Basin			Product	Pounds		2	0.4025	Product	Pounds				Product	Pounds	
Cemetery vases			Product	Pounds				Product	Pounds				Product	Pounds	
Channel			Product	Pounds				Product	Pounds				Product	Pounds	
Clean Pool			Product	Pounds				Product	Pounds				Product	Pounds	
Commercial			Product	Pounds				Product	Pounds				Product	Pounds	
Container			Product	Pounds				Product	Pounds				Product	Pounds	
Creek	1	8	Product	Pounds		2	0.253575	Product	Pounds		5	1.725	Product	Pounds	
Curbs			Product	Pounds		2	0.161	Product	Pounds				Product	Pounds	
Dairy Drain			Product	Pounds				Product	Pounds				Product	Pounds	
Diked Marsh			Product	Pounds				Product	Pounds				Product	Pounds	
Drain			Product	Pounds				Product	Pounds				Product	Pounds	
Duck Pond			Product	Pounds				Product	Pounds				Product	Pounds	
Flooded Area			Product	Pounds				Product	Pounds				Product	Pounds	
FW Marsh			Product	Pounds				Product	Pounds				Product	Pounds	
Impound			Product	Pounds				Product	Pounds				Product	Pounds	
Lake			Product	Pounds				Product	Pounds				Product	Pounds	
Lift Station			Product	Pounds				Product	Pounds				Product	Pounds	
Neglected Pool			Product	Pounds		2	0.322	Product	Pounds				Product	Pounds	
Ornamental Pond			Product	Pounds				Product	Pounds				Product	Pounds	
Pond			Product	Pounds				Product	Pounds				Product	Pounds	
Residential			Product	Pounds		1	0.161	Product	Pounds				Product	Pounds	
Salt Marsh			Product	Pounds				Product	Pounds				Product	Pounds	
Sewer Pond			Product	Pounds				Product	Pounds				Product	Pounds	
Tires			Product	Pounds				Product	Pounds				Product	Pounds	
Treehole			Product	Pounds				Product	Pounds				Product	Pounds	
Utility Vault			Product	Pounds				Product	Pounds				Product	Pounds	
Watering Trough			Product	Pounds				Product	Pounds				Product	Pounds	
Totals	1	8	Product	Pounds		9	1.300075	Product	Pounds		5	1.725	Product	Pounds	

Table A32.

Application Sites:	BVA 2 Mosquito Larvi-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	BVA 2 Mosquito Larvi Comments	Contrac 8oz blk-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Contrac 8oz blk Comments	Diphacinone-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Diphacinone Comments
			Product	Gallons				Product					Product	Pounds	
Catch Basin	2	0.054875	Product	Gallons				Product					Product	Pounds	
Cemetery vases	3	0.148875	Product	Gallons				Product					Product	Pounds	
Channel	2	0.013313	Product	Gallons				Product					Product	Pounds	
Clean Pool	4	0.035157	Product	Gallons				Product					Product	Pounds	
Commercial	1	0.006875	Product	Gallons				Product					Product	Pounds	
Container			Product	Gallons				Product					Product	Pounds	
Creek	24	0.53222	Product	Gallons				Product					Product	Pounds	
Curbs	18	1.219219	Product	Gallons				Product					Product	Pounds	
Dairy Drain	1	0.004125	Product	Gallons				Product					Product	Pounds	
Diked Marsh			Product	Gallons				Product					Product	Pounds	
Drain			Product	Gallons				Product					Product	Pounds	
Duck Pond			Product	Gallons				Product					Product	Pounds	
Flooded Area	5	0.29975	Product	Gallons				Product					Product	Pounds	
FW Marsh	2	0.011	Product	Gallons				Product					Product	Pounds	
Impound	2	0.03675	Product	Gallons				Product					Product	Pounds	
Lake			Product	Gallons				Product					Product	Pounds	
Lift Station			Product	Gallons				Product					Product	Pounds	
Neglected Pool	8	0.099126	Product	Gallons				Product					Product	Pounds	
Ornamental Pond	1	0.006875	Product	Gallons				Product					Product	Pounds	
Pond			Product	Gallons				Product					Product	Pounds	
Residential			Product	Gallons		2		Product			1		Product	Pounds	
Salt Marsh	2	3.5825	Product	Gallons				Product					Product	Pounds	
Sewer Pond	2	0.221375	Product	Gallons				Product					Product	Pounds	
Tires			Product	Gallons				Product					Product	Pounds	
Treehole			Product	Gallons				Product					Product	Pounds	
Utility Vault	1	0.015625	Product	Gallons				Product					Product	Pounds	
Watering Trough			Product	Gallons				Product					Product	Pounds	
Totals	78	6.28766	Product	Gallons		2		Product			1		Product	Pounds	

Table A32.

Application Sites:	Drione Insecticide-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Drione Insecticide Comments	FirstStrike Soft Bai-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	FirstStrike Soft Bai Comments	Fourstar 180 briq-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Fourstar 180 briq Comments
			Product	Pounds				Product			1	0.0625	Product	Pounds	
Catch Basin			Product	Pounds				Product			1	1.5	Product	Pounds	
Cemetery vases			Product	Pounds				Product					Product	Pounds	
Channel			Product	Pounds				Product			1	0.625	Product	Pounds	
Clean Pool			Product	Pounds				Product					Product	Pounds	
Commercial			Product	Pounds		1		Product			1	0.125	Product	Pounds	
Container			Product	Pounds				Product					Product	Pounds	
Creek			Product	Pounds				Product			32	9.625	Product	Pounds	
Curbs			Product	Pounds				Product			3	0.75	Product	Pounds	
Dairy Drain			Product	Pounds				Product					Product	Pounds	
Diked Marsh			Product	Pounds				Product					Product	Pounds	
Drain			Product	Pounds				Product					Product	Pounds	
Duck Pond			Product	Pounds				Product					Product	Pounds	
Flooded Area			Product	Pounds				Product			1	0.0625	Product	Pounds	
FW Marsh			Product	Pounds				Product			1	0.25	Product	Pounds	
Impound			Product	Pounds				Product					Product	Pounds	
Lake			Product	Pounds				Product					Product	Pounds	
Lift Station			Product	Pounds				Product					Product	Pounds	
Neglected Pool			Product	Pounds				Product					Product	Pounds	
Ornamental Pond			Product	Pounds				Product			2	0.125	Product	Pounds	
Pond			Product	Pounds				Product			3	0.375	Product	Pounds	
Residential	2	0.0625	Product	Pounds		1		Product					Product	Pounds	
Salt Marsh			Product	Pounds				Product					Product	Pounds	
Sewer Pond			Product	Pounds				Product			1	0.0625	Product	Pounds	
Tires			Product	Pounds				Product					Product	Pounds	
Treehole	1	0.015625	Product	Pounds				Product					Product	Pounds	
Utility Vault			Product	Pounds				Product					Product	Pounds	
Watering Trough			Product	Pounds				Product			1	0.3125	Product	Pounds	
Totals	3	0.078125	Product	Pounds		2		Product			48	13.875	Product	Pounds	

Table A32.

Application Sites:	Fourstar 45 briq-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Fourstar 45 briq Comments	Fourstar 90 briq-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Fourstar 90 briq Comments	Golden Bear 1111 Oil-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Golden Bear 1111 Oil Comments
			Product	Pounds				Product	Pounds				Product	Gallons	
Catch Basin	1	0.03125	Product	Pounds				Product	Pounds				Product	Gallons	
Cemetery vases			Product	Pounds				Product	Pounds				Product	Gallons	
Channel			Product	Pounds		1	0.1875	Product	Pounds				Product	Gallons	
Clean Pool			Product	Pounds				Product	Pounds				Product	Gallons	
Commercial			Product	Pounds				Product	Pounds				Product	Gallons	
Container			Product	Pounds				Product	Pounds				Product	Gallons	
Creek	4	0.320313	Product	Pounds		2	0.1875	Product	Pounds		2	0.028875	Product	Gallons	
Curbs	1	0.007813	Product	Pounds		2	0.09375	Product	Pounds				Product	Gallons	
Dairy Drain			Product	Pounds				Product	Pounds				Product	Gallons	
Diked Marsh			Product	Pounds				Product	Pounds				Product	Gallons	
Drain			Product	Pounds				Product	Pounds				Product	Gallons	
Duck Pond			Product	Pounds				Product	Pounds				Product	Gallons	
Flooded Area			Product	Pounds				Product	Pounds				Product	Gallons	
FW Marsh			Product	Pounds		1	0.03125	Product	Pounds				Product	Gallons	
Impound			Product	Pounds				Product	Pounds				Product	Gallons	
Lake			Product	Pounds				Product	Pounds				Product	Gallons	
Lift Station	1	0.015625	Product	Pounds				Product	Pounds				Product	Gallons	
Neglected Pool			Product	Pounds				Product	Pounds				Product	Gallons	
Ornamental Pond			Product	Pounds				Product	Pounds				Product	Gallons	
Pond			Product	Pounds				Product	Pounds				Product	Gallons	
Residential			Product	Pounds				Product	Pounds				Product	Gallons	
Salt Marsh			Product	Pounds				Product	Pounds				Product	Gallons	
Sewer Pond	6	0.703127	Product	Pounds				Product	Pounds				Product	Gallons	
Tires			Product	Pounds				Product	Pounds				Product	Gallons	
Treehole			Product	Pounds				Product	Pounds				Product	Gallons	
Utility Vault			Product	Pounds				Product	Pounds				Product	Gallons	
Watering Trough			Product	Pounds				Product	Pounds				Product	Gallons	
Totals	13	1.078128	Product	Pounds		6	0.5	Product	Pounds		2	0.028875	Product	Gallons	

Table A32.

Application Sites:	Vectobac 12AS-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Vectobac 12AS Comments	Vectobac G-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Vectobac G Comments	Vectolex CG-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Vectolex CG Comments
			Product	Gallons		1	0.15	Product	Pounds				Product	Pounds	
Catch Basin	1	0.004014	Product	Gallons				Product	Pounds				Product	Pounds	
Cemetery vases			Product	Gallons		2	0.598	Product	Pounds				Product	Pounds	
Channel	3	0.094783	Product	Gallons		4	12.788	Product	Pounds				Product	Pounds	
Clean Pool			Product	Gallons				Product	Pounds				Product	Pounds	
Commercial	1	0.000287	Product	Gallons				Product	Pounds				Product	Pounds	
Container			Product	Gallons				Product	Pounds				Product	Pounds	
Creek	25	0.970037	Product	Gallons		58	71.9533	Product	Pounds		22	19.3485	Product	Pounds	
Curbs	7	51.349999	Product	Gallons		4	47.107	Product	Pounds		1	40	Product	Pounds	
Dairy Drain			Product	Gallons				Product	Pounds				Product	Pounds	
Diked Marsh	5	0.802525	Product	Gallons				Product	Pounds				Product	Pounds	
Drain			Product	Gallons				Product	Pounds				Product	Pounds	
Duck Pond	2	0.15	Product	Gallons				Product	Pounds				Product	Pounds	
Flooded Area	1	0.014623	Product	Gallons		6	5.236	Product	Pounds				Product	Pounds	
FW Marsh			Product	Gallons		5	146.58	Product	Pounds		2	16	Product	Pounds	
Impound			Product	Gallons		1	0.092	Product	Pounds				Product	Pounds	
Lake	1	0.011755	Product	Gallons				Product	Pounds				Product	Pounds	
Lift Station	1	0.00172	Product	Gallons		1	0.138	Product	Pounds				Product	Pounds	
Neglected Pool	1	0.001094	Product	Gallons		2	0.98	Product	Pounds		1	0.253	Product	Pounds	
Ornamental Pond			Product	Gallons		2	0.0276	Product	Pounds		2	0.0276	Product	Pounds	
Pond	1	0.000573	Product	Gallons				Product	Pounds				Product	Pounds	
Residential			Product	Gallons		1	0.092	Product	Pounds				Product	Pounds	
Salt Marsh	1	0.03928	Product	Gallons		5	12.65	Product	Pounds		2	0.46	Product	Pounds	
Sewer Pond	6	3.085915	Product	Gallons		1	4.002	Product	Pounds				Product	Pounds	
Tires			Product	Gallons				Product	Pounds				Product	Pounds	
Treehole			Product	Gallons				Product	Pounds				Product	Pounds	
Utility Vault			Product	Gallons				Product	Pounds				Product	Pounds	
Watering Trough			Product	Gallons				Product	Pounds				Product	Pounds	
Totals	56	56.526605	Product	Gallons		93	302.3939	Product	Pounds		30	76.0891	Product	Pounds	

Table A32.

Application Sites:	Vectomax CG-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Vectomax CG Comments
			Product	Pounds	
Catch Basin			Product	Pounds	
Cemetery vases			Product	Pounds	
Channel			Product	Pounds	
Clean Pool			Product	Pounds	
Commercial			Product	Pounds	
Container			Product	Pounds	
Creek			Product	Pounds	
Curbs	1	1.311	Product	Pounds	
Dairy Drain			Product	Pounds	
Diked Marsh			Product	Pounds	
Drain			Product	Pounds	
Duck Pond			Product	Pounds	
Flooded Area			Product	Pounds	
FW Marsh			Product	Pounds	
Impound			Product	Pounds	
Lake			Product	Pounds	
Lift Station			Product	Pounds	
Neglected Pool			Product	Pounds	
Ornamental Pond			Product	Pounds	
Pond			Product	Pounds	
Residential			Product	Pounds	
Salt Marsh			Product	Pounds	
Sewer Pond	3	1.541	Product	Pounds	
Tires			Product	Pounds	
Treehole			Product	Pounds	
Utility Vault			Product	Pounds	
Watering Trough			Product	Pounds	
Totals	4	2.852	Product	Pounds	

Table A33. Pesticide Application Data for Winter 2012 – SCCVCD

Application Sites:	Agnique MMF-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Agnique MMF Comments	AGNIQUE MMF G-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	AGNIQUE MMF G Comments	Altosid Briquets 30-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Altosid Briquets 30 Comments
			Product	Gallons				Product	Pounds				Product	Pounds	
Channel			Product	Gallons				Product	Pounds				Product	Pounds	
Clean Pool			Product	Gallons				Product	Pounds				Product	Pounds	
Commercial			Product	Gallons				Product	Pounds				Product	Pounds	
Container	1	0.004591	Product	Gallons		1	0.0494	Product	Pounds				Product	Pounds	
Creek			Product	Gallons		3	2.2477	Product	Pounds		1	0.075	Product	Pounds	
Curbs	1	0.001148	Product	Gallons		3	0.3705	Product	Pounds				Product	Pounds	
Diked Marsh			Product	Gallons				Product	Pounds				Product	Pounds	
Fish Pond	1	0.001148	Product	Gallons				Product	Pounds				Product	Pounds	
Flooded Area	1	0.036725	Product	Gallons				Product	Pounds				Product	Pounds	
FW Marsh			Product	Gallons				Product	Pounds				Product	Pounds	
Impound	1	0.040168	Product	Gallons				Product	Pounds				Product	Pounds	
Lift Station			Product	Gallons				Product	Pounds				Product	Pounds	
Neglected Pool	3	0.029839	Product	Gallons				Product	Pounds				Product	Pounds	
Ornamental Pond			Product	Gallons				Product	Pounds				Product	Pounds	
Pond	2	0.004591	Product	Gallons		1	0.0247	Product	Pounds				Product	Pounds	
Residential			Product	Gallons				Product	Pounds				Product	Pounds	
Salt Marsh			Product	Gallons				Product	Pounds				Product	Pounds	
Seepage			Product	Gallons				Product	Pounds				Product	Pounds	
Sewer Pond			Product	Gallons				Product	Pounds				Product	Pounds	
Watering Trough			Product	Gallons				Product	Pounds				Product	Pounds	
Totals	10	0.11821	Product	Gallons		8	2.6923	Product	Pounds		1	0.075	Product	Pounds	

Table A33.

Application Sites:	Altosid Liquid SR5-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Altosid Liquid SR5 Comments	Altosid XR Briquets-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Altosid XR Briquets Comments	Altosid XR-G-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Altosid XR-G Comments
			Product	Gallons				Product	Pounds				Product	Pounds	
Channel			Product	Gallons		2	0.7245	Product	Pounds				Product	Pounds	
Clean Pool			Product	Gallons				Product	Pounds				Product	Pounds	
Commercial			Product	Gallons				Product	Pounds				Product	Pounds	
Container			Product	Gallons		1	0.2415	Product	Pounds				Product	Pounds	
Creek			Product	Gallons		4	0.8855	Product	Pounds		2	0.851	Product	Pounds	
Curbs			Product	Gallons		1	0.161	Product	Pounds		4	0.943	Product	Pounds	
Diked Marsh			Product	Gallons				Product	Pounds				Product	Pounds	
Fish Pond			Product	Gallons				Product	Pounds				Product	Pounds	
Flooded Area			Product	Gallons				Product	Pounds		1	0.184	Product	Pounds	
FW Marsh	1	0.3125	Product	Gallons				Product	Pounds				Product	Pounds	
Impound			Product	Gallons				Product	Pounds				Product	Pounds	
Lift Station			Product	Gallons				Product	Pounds				Product	Pounds	
Neglected Pool			Product	Gallons		2	0.161	Product	Pounds				Product	Pounds	
Ornamental Pond			Product	Gallons		1	0.0805	Product	Pounds				Product	Pounds	
Pond			Product	Gallons				Product	Pounds				Product	Pounds	
Residential			Product	Gallons				Product	Pounds				Product	Pounds	
Salt Marsh			Product	Gallons				Product	Pounds				Product	Pounds	
Seepage			Product	Gallons				Product	Pounds				Product	Pounds	
Sewer Pond			Product	Gallons				Product	Pounds				Product	Pounds	
Watering Trough			Product	Gallons				Product	Pounds				Product	Pounds	
Totals	1	0.3125	Product	Gallons		11	2.254	Product	Pounds		7	1.978	Product	Pounds	

Table A33.

Application Sites:	BVA 2 Mosquito Larvi-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	BVA 2 Mosquito Larvi Comments	Fourstar 180 briq-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Fourstar 180 briq Comments	Fourstar 45 briq-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Fourstar 45 briq Comments
			Product	Gallons				Product	Pounds		1	0.101563	Product	Pounds	
Channel	3	0.132813	Product	Gallons				Product	Pounds		4	0.468751	Product	Pounds	
Clean Pool			Product	Gallons		1	0.0625	Product	Pounds				Product	Pounds	
Commercial			Product	Gallons				Product	Pounds				Product	Pounds	
Container	2	0.0165	Product	Gallons		1	0.1875	Product	Pounds				Product	Pounds	
Creek	15	0.829595	Product	Gallons		13	5.25	Product	Pounds		21	14.76563	Product	Pounds	
Curbs	4	0.197063	Product	Gallons		4	0.5625	Product	Pounds		9	0.656252	Product	Pounds	
Diked Marsh	1	1.375	Product	Gallons				Product	Pounds				Product	Pounds	
Fish Pond			Product	Gallons		2	0.125	Product	Pounds				Product	Pounds	
Flooded Area	2	0.188375	Product	Gallons		1	1	Product	Pounds				Product	Pounds	
FW Marsh			Product	Gallons				Product	Pounds				Product	Pounds	
Impound	1	0.041323	Product	Gallons				Product	Pounds				Product	Pounds	
Lift Station			Product	Gallons				Product	Pounds				Product	Pounds	
Neglected Pool	4	0.198125	Product	Gallons				Product	Pounds		2	0.054688	Product	Pounds	
Ornamental Pond	1	0.001375	Product	Gallons		2	0.125	Product	Pounds		1	0.03125	Product	Pounds	
Pond			Product	Gallons				Product	Pounds		2	0.031251	Product	Pounds	
Residential			Product	Gallons				Product	Pounds				Product	Pounds	
Salt Marsh			Product	Gallons				Product	Pounds				Product	Pounds	
Seepage			Product	Gallons				Product	Pounds				Product	Pounds	
Sewer Pond			Product	Gallons				Product	Pounds		1	0.15625	Product	Pounds	
Watering Trough			Product	Gallons				Product	Pounds				Product	Pounds	
Totals	33	2.980169	Product	Gallons		24	7.3125	Product	Pounds		41	16.265635	Product	Pounds	

Table A33.

Application Sites:	Fourstar 90 briq-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Fourstar 90 briq Comments	Golden Bear 1111 Oil-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Golden Bear 1111 Oil Comments	Vectobac 12AS-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Vectobac 12AS Comments
			Product	Pounds				Product	Gallons		1	0.023438	Product	Gallons	
Channel			Product	Pounds				Product	Gallons		1	0.006021	Product	Gallons	
Clean Pool			Product	Pounds				Product	Gallons				Product	Gallons	
Commercial			Product	Pounds				Product	Gallons		1	0.072827	Product	Gallons	
Container	1	0.03125	Product	Pounds		1	0.000156	Product	Gallons		1	0.000016	Product	Gallons	
Creek	2	0.15625	Product	Pounds				Product	Gallons		20	0.656871	Product	Gallons	
Curbs			Product	Pounds				Product	Gallons		2	0.036987	Product	Gallons	
Diked Marsh			Product	Pounds		1	0.776875	Product	Gallons		10	1.138848	Product	Gallons	
Fish Pond			Product	Pounds				Product	Gallons				Product	Gallons	
Flooded Area			Product	Pounds				Product	Gallons		3	1.250578	Product	Gallons	
FW Marsh			Product	Pounds				Product	Gallons		1	2.5	Product	Gallons	
Impound			Product	Pounds				Product	Gallons				Product	Gallons	
Lift Station			Product	Pounds				Product	Gallons		1	0.00172	Product	Gallons	
Neglected Pool	1	0.0625	Product	Pounds				Product	Gallons				Product	Gallons	
Ornamental Pond			Product	Pounds				Product	Gallons		1	0.000573	Product	Gallons	
Pond			Product	Pounds				Product	Gallons		4	0.332021	Product	Gallons	
Residential			Product	Pounds				Product	Gallons				Product	Gallons	
Salt Marsh			Product	Pounds				Product	Gallons		22	34.329229	Product	Gallons	
Seepage			Product	Pounds				Product	Gallons				Product	Gallons	
Sewer Pond			Product	Pounds				Product	Gallons		6	0.524981	Product	Gallons	
Watering Trough	1	0.15625	Product	Pounds				Product	Gallons				Product	Gallons	
Totals	5	0.40625	Product	Pounds		2	0.777031	Product	Gallons		74	40.87411	Product	Gallons	

Table A33.

Application Sites:	Vectobac G-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Vectobac G Comments	Vectolex CG-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Vectolex CG Comments	Vectomax CG-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Vectomax CG Comments
	1	1.012	Product	Pounds				Product	Pounds				Product	Pounds	
Channel			Product	Pounds				Product	Pounds				Product	Pounds	
Clean Pool			Product	Pounds				Product	Pounds				Product	Pounds	
Commercial			Product	Pounds				Product	Pounds				Product	Pounds	
Container	1	0.046	Product	Pounds				Product	Pounds				Product	Pounds	
Creek	3	2.047	Product	Pounds				Product	Pounds				Product	Pounds	
Curbs	2	0.207	Product	Pounds				Product	Pounds				Product	Pounds	
Diked Marsh	1	38	Product	Pounds				Product	Pounds				Product	Pounds	
Fish Pond			Product	Pounds				Product	Pounds				Product	Pounds	
Flooded Area	6	5.865	Product	Pounds				Product	Pounds				Product	Pounds	
FW Marsh	5	25.98	Product	Pounds		5	25.98	Product	Pounds				Product	Pounds	
Impound	1	1.1433	Product	Pounds				Product	Pounds				Product	Pounds	
Lift Station	2	25	Product	Pounds				Product	Pounds				Product	Pounds	
Neglected Pool	1	0.23	Product	Pounds				Product	Pounds				Product	Pounds	
Ornamental Pond	1	0.069	Product	Pounds				Product	Pounds				Product	Pounds	
Pond	4	5.497	Product	Pounds				Product	Pounds				Product	Pounds	
Residential	1	0.046	Product	Pounds				Product	Pounds				Product	Pounds	
Salt Marsh	21	164.855	Product	Pounds		5	7.427	Product	Pounds		2	26	Product	Pounds	
Seepage	1	0.506	Product	Pounds				Product	Pounds				Product	Pounds	
Sewer Pond	2	9.085	Product	Pounds				Product	Pounds				Product	Pounds	
Watering Trough			Product	Pounds				Product	Pounds				Product	Pounds	
Totals	53	279.5883	Product	Pounds		10	33.407	Product	Pounds		2	26	Product	Pounds	

Table A34. Pesticide Application Data for Spring 2012 – SCCVCD

Application Sites:	Agnique MMF-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Agnique MMF Comments	AGNIQUE MMF G-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	AGNIQUE MMF G Comments	Altosid Briquets 30-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Altosid Briquets 30 Comments
			Product	Gallons				Product	Pounds				Product	Pounds	
Channel			Product	Gallons				Product	Pounds				Product	Pounds	
Clean Pool			Product	Gallons				Product	Pounds				Product	Pounds	
Commercial			Product	Gallons				Product	Pounds				Product	Pounds	
Container	1	0.004591	Product	Gallons		1	0.0494	Product	Pounds				Product	Pounds	
Creek			Product	Gallons		3	2.2477	Product	Pounds		1	0.075	Product	Pounds	
Curbs	1	0.001148	Product	Gallons		3	0.3705	Product	Pounds				Product	Pounds	
Diked Marsh			Product	Gallons				Product	Pounds				Product	Pounds	
Fish Pond	1	0.001148	Product	Gallons				Product	Pounds				Product	Pounds	
Flooded Area	1	0.036725	Product	Gallons				Product	Pounds				Product	Pounds	
FW Marsh			Product	Gallons				Product	Pounds				Product	Pounds	
Impound	1	0.040168	Product	Gallons				Product	Pounds				Product	Pounds	
Lift Station			Product	Gallons				Product	Pounds				Product	Pounds	
Neglected Pool	3	0.029839	Product	Gallons				Product	Pounds				Product	Pounds	
Ornamental Pond			Product	Gallons				Product	Pounds				Product	Pounds	
Pond	2	0.004591	Product	Gallons		1	0.0247	Product	Pounds				Product	Pounds	
Residential			Product	Gallons				Product	Pounds				Product	Pounds	
Salt Marsh			Product	Gallons				Product	Pounds				Product	Pounds	
Seepage			Product	Gallons				Product	Pounds				Product	Pounds	
Sewer Pond			Product	Gallons				Product	Pounds				Product	Pounds	
Watering Trough			Product	Gallons				Product	Pounds				Product	Pounds	
Totals	10	0.11821	Product	Gallons		8	2.6923	Product	Pounds		1	0.075	Product	Pounds	

Table A34.

Application Sites:	Altosid Liquid SR5-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Altosid Liquid SR5 Comments	Altosid XR Briquets-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Altosid XR Briquets Comments	Altosid XR-G-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Altosid XR-G Comments
			Product	Gallons				Product	Pounds				Product	Pounds	
Channel			Product	Gallons		2	0.7245	Product	Pounds				Product	Pounds	
Clean Pool			Product	Gallons				Product	Pounds				Product	Pounds	
Commercial			Product	Gallons				Product	Pounds				Product	Pounds	
Container			Product	Gallons		1	0.2415	Product	Pounds				Product	Pounds	
Creek			Product	Gallons		4	0.8855	Product	Pounds		2	0.851	Product	Pounds	
Curbs			Product	Gallons		1	0.161	Product	Pounds		4	0.943	Product	Pounds	
Diked Marsh			Product	Gallons				Product	Pounds				Product	Pounds	
Fish Pond			Product	Gallons				Product	Pounds				Product	Pounds	
Flooded Area			Product	Gallons				Product	Pounds		1	0.184	Product	Pounds	
FW Marsh	1	0.3125	Product	Gallons				Product	Pounds				Product	Pounds	
Impound			Product	Gallons				Product	Pounds				Product	Pounds	
Lift Station			Product	Gallons				Product	Pounds				Product	Pounds	
Neglected Pool			Product	Gallons		2	0.161	Product	Pounds				Product	Pounds	
Ornamental Pond			Product	Gallons		1	0.0805	Product	Pounds				Product	Pounds	
Pond			Product	Gallons				Product	Pounds				Product	Pounds	
Residential			Product	Gallons				Product	Pounds				Product	Pounds	
Salt Marsh			Product	Gallons				Product	Pounds				Product	Pounds	
Seepage			Product	Gallons				Product	Pounds				Product	Pounds	
Sewer Pond			Product	Gallons				Product	Pounds				Product	Pounds	
Watering Trough			Product	Gallons				Product	Pounds				Product	Pounds	
Totals	1	0.3125	Product	Gallons		11	2.254	Product	Pounds		7	1.978	Product	Pounds	

Table A34.

Application Sites:	BVA 2 Mosquito Larvi-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	BVA 2 Mosquito Larvi Comments	Fourstar 180 briq-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Fourstar 180 briq Comments	Fourstar 45 briq-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Fourstar 45 briq Comments
			Product	Gallons				Product	Pounds		1	0.101563	Product	Pounds	
Channel	3	0.132813	Product	Gallons				Product	Pounds		4	0.468751	Product	Pounds	
Clean Pool			Product	Gallons		1	0.0625	Product	Pounds				Product	Pounds	
Commercial			Product	Gallons				Product	Pounds				Product	Pounds	
Container	2	0.0165	Product	Gallons		1	0.1875	Product	Pounds				Product	Pounds	
Creek	15	0.829595	Product	Gallons		13	5.25	Product	Pounds		21	14.76563	Product	Pounds	
Curbs	4	0.197063	Product	Gallons		4	0.5625	Product	Pounds		9	0.656252	Product	Pounds	
Diked Marsh	1	1.375	Product	Gallons				Product	Pounds				Product	Pounds	
Fish Pond			Product	Gallons		2	0.125	Product	Pounds				Product	Pounds	
Flooded Area	2	0.188375	Product	Gallons		1	1	Product	Pounds				Product	Pounds	
FW Marsh			Product	Gallons				Product	Pounds				Product	Pounds	
Impound	1	0.041323	Product	Gallons				Product	Pounds				Product	Pounds	
Lift Station			Product	Gallons				Product	Pounds				Product	Pounds	
Neglected Pool	4	0.198125	Product	Gallons				Product	Pounds		2	0.054688	Product	Pounds	
Ornamental Pond	1	0.001375	Product	Gallons		2	0.125	Product	Pounds		1	0.03125	Product	Pounds	
Pond			Product	Gallons				Product	Pounds		2	0.031251	Product	Pounds	
Residential			Product	Gallons				Product	Pounds				Product	Pounds	
Salt Marsh			Product	Gallons				Product	Pounds				Product	Pounds	
Seepage			Product	Gallons				Product	Pounds				Product	Pounds	
Sewer Pond			Product	Gallons				Product	Pounds		1	0.15625	Product	Pounds	
Watering Trough			Product	Gallons				Product	Pounds				Product	Pounds	
Totals	33	2.980169	Product	Gallons		24	7.3125	Product	Pounds		41	16.265635	Product	Pounds	

Table A34.

Application Sites:	Fourstar 90 briq-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Fourstar 90 briq Comments	Golden Bear 1111 Oil-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Golden Bear 1111 Oil Comments	Vectobac 12AS-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Vectobac 12AS Comments
			Product	Pounds				Product	Gallons		1	0.023438	Product	Gallons	
Channel			Product	Pounds				Product	Gallons		1	0.006021	Product	Gallons	
Clean Pool			Product	Pounds				Product	Gallons				Product	Gallons	
Commercial			Product	Pounds				Product	Gallons		1	0.072827	Product	Gallons	
Container	1	0.03125	Product	Pounds		1	0.000156	Product	Gallons		1	0.000016	Product	Gallons	
Creek	2	0.15625	Product	Pounds				Product	Gallons		20	0.656871	Product	Gallons	
Curbs			Product	Pounds				Product	Gallons		2	0.036987	Product	Gallons	
Diked Marsh			Product	Pounds		1	0.776875	Product	Gallons		10	1.138848	Product	Gallons	
Fish Pond			Product	Pounds				Product	Gallons				Product	Gallons	
Flooded Area			Product	Pounds				Product	Gallons		3	1.250578	Product	Gallons	
FW Marsh			Product	Pounds				Product	Gallons		1	2.5	Product	Gallons	
Impound			Product	Pounds				Product	Gallons				Product	Gallons	
Lift Station			Product	Pounds				Product	Gallons		1	0.00172	Product	Gallons	
Neglected Pool	1	0.0625	Product	Pounds				Product	Gallons				Product	Gallons	
Ornamental Pond			Product	Pounds				Product	Gallons		1	0.000573	Product	Gallons	
Pond			Product	Pounds				Product	Gallons		4	0.332021	Product	Gallons	
Residential			Product	Pounds				Product	Gallons				Product	Gallons	
Salt Marsh			Product	Pounds				Product	Gallons		22	34.329229	Product	Gallons	
Seepage			Product	Pounds				Product	Gallons				Product	Gallons	
Sewer Pond			Product	Pounds				Product	Gallons		6	0.524981	Product	Gallons	
Watering Trough	1	0.15625	Product	Pounds				Product	Gallons				Product	Gallons	
Totals	5	0.40625	Product	Pounds		2	0.777031	Product	Gallons		74	40.87411	Product	Gallons	

Table A34.

Application Sites:	Vectobac G-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Vectobac G Comments	Vectolex CG-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Vectolex CG Comments	Vectomax CG-# Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Vectomax CG Comments
	1	1.012	Product	Pounds				Product	Pounds				Product	Pounds	
Channel			Product	Pounds				Product	Pounds				Product	Pounds	
Clean Pool			Product	Pounds				Product	Pounds				Product	Pounds	
Commercial			Product	Pounds				Product	Pounds				Product	Pounds	
Container	1	0.046	Product	Pounds				Product	Pounds				Product	Pounds	
Creek	3	2.047	Product	Pounds				Product	Pounds				Product	Pounds	
Curbs	2	0.207	Product	Pounds				Product	Pounds				Product	Pounds	
Diked Marsh	1	38	Product	Pounds				Product	Pounds				Product	Pounds	
Fish Pond			Product	Pounds				Product	Pounds				Product	Pounds	
Flooded Area	6	5.865	Product	Pounds				Product	Pounds				Product	Pounds	
FW Marsh	5	25.98	Product	Pounds		5	25.98	Product	Pounds				Product	Pounds	
Impound	1	1.1433	Product	Pounds				Product	Pounds				Product	Pounds	
Lift Station	2	25	Product	Pounds				Product	Pounds				Product	Pounds	
Neglected Pool	1	0.23	Product	Pounds				Product	Pounds				Product	Pounds	
Ornamental Pond	1	0.069	Product	Pounds				Product	Pounds				Product	Pounds	
Pond	4	5.497	Product	Pounds				Product	Pounds				Product	Pounds	
Residential	1	0.046	Product	Pounds				Product	Pounds				Product	Pounds	
Salt Marsh	21	164.855	Product	Pounds		5	7.427	Product	Pounds		2	26	Product	Pounds	
Seepage	1	0.506	Product	Pounds				Product	Pounds				Product	Pounds	
Sewer Pond	2	9.085	Product	Pounds				Product	Pounds				Product	Pounds	
Watering Trough			Product	Pounds				Product	Pounds				Product	Pounds	
Totals	53	279.5883	Product	Pounds		10	33.407	Product	Pounds		2	26	Product	Pounds	

Table A35. Pesticide Product Key – SCCVCD

Product	AI	Vector
Agnique MMF	Biodegradable Alcohol Ethoxylated Surfactant	Mosquito
Agnique MMF G	Biodegradable Alcohol Ethoxylated Surfactant	Mosquito
Altosid Briquets 30	Methoprene	Mosquito
Altosid Liquid SR5	Methoprene	Mosquito
Altosid Pellets	Methoprene	Mosquito
Altosid XR Briquets	Methoprene	Mosquito
Altosid XR-G	Methoprene	Mosquito
BVA 2	Petroleum Distillate	Mosquito
Contrac 8 oz blk	Bromadiolone	Rat
Drione Insecticide	Pyrethrin	Yellow Jacket / Wasp
FirstStrike Soft Bait	Difethialone	Rat
FourStar 180 Bs	Bacillus Sphaericus and Bacillus Thuringiensis Israelensis	Mosquito
FourStar 45 Bti	Bacillus Sphaericus and Bacillus Thuringiensis Israelensis	Mosquito
FourStar 90 briq	Bacillus Sphaericus and Bacillus Thuringiensis Israelensis	Mosquito
Pyrenone 25-5	Pyrethrins and Piperonyl Butoxide	Mosquito
VectoBac 12AS	Bacillus Thuringiensis Israelensis	Mosquito
VectoBac G	Bacillus Thuringiensis Israelensis	Mosquito
VectoLex CG Biologic	Bacillus Sphaericus	Mosquito
VectoLex WSP	Bacillus Sphaericus	Mosquito
VectoMax CG	Bacillus Sphaericus and Bacillus Thuringiensis Israelensis	Mosquito
Diphacinone	Active Ingredient in Ditrac blox for rats	
EcoExempt IC2	Rosemary Oil	Mosquito
Golden Bear 1111	Aliphatic Petroleum Hydrocarbons	Mosquito

Table A36. **Pesticide Application Data for Summer 2011 – SCMAD**

Application Sites:	Altosid Liquid SR5 - # Treatments	Total Amount Used4	Total Amount Type5	Total Amount Unit5	Altosid Liquid SR5 Comments	Altosid XR Extended Residual - # Treatments	Total Amount Used13	Total Amount Type14	Total Amount Unit14	Altosid XR Extended Residual Comments	Altosid SBG - # Treatments	Total Amount Used15	Total Amount Type16	Total Amount Unit16	Altosid SBG Comments	Scourge 18%+12% - # Treatments	Total Amount Used25	Total Amount Type26	Total Amount Unit26	Scourge 18%+54% Comments	FourStar 180 Bs/Bti - # Treatments	Total Amount Used35	Total Amount Type36	Total Amount Unit36	FourStar 180 Bs/Bti Comments	MGK Pyrocide Fogging Concentrate 7396 - # Treatments
1. Swimming pool **(00100)**						41	41.770	Product	Pounds												2	0.727	Product	Pounds		
2. Ponds **(00385)**						1	0.960	Product	Pounds																	
3. Water trough **(00390)**																										
4. Retention basin **(00400)**																										
5. Manmade pond **(00480)**																										
6. Fish pond **(01096)**																										
7. Dredge spoil pond **(01276)**																										
8. Permanent pond **(03240)**																										
9. Alfalfa **(00020)**																										3
10. Row crop **(00050)**																										
11. Contour pasture **(00435)**																										7
12. Pasture ditch **(00440)**																										
13. Flooded pasture **(00470)**																										55
14. Strip check pasture **(00495)**																										4
15. Sump (**00500**)																					1	0.132	Product	Pounds		
16. Tail water drain **(00505)**																										
17. Septic tank **(01038)**																										
18. Container **(01045)**																										
19. Tires **(01060)**																										
20. Waterline leak **(01288)**																										2
21. Electrical box **(01624)**																										
22. Catch basin **(01699)**																					1	0.132	Product	Pounds		
23. Valve box **(02460)**																										
24. Waste/sewer pond **(02480)**																										
25. Roadside ditch **(01705)**																										
26. Depression/swale **(03120)**																										2
27. Duck Club/seasonal waterfowl habitat **(00700)**	13	31.4375	Product	Gallons							2	840.000	Product	Pounds												65
28. Tidal marsh **(03130)**	1	5.9375	Product	Gallons																						
29. Reclaimed marsh **(03230)**																										
30A. Reclaimed marsh/other **(03231)**																										
31. Streams/creeks **(03440)**																										
32. Treehole **(03480)**																										3
33. Vernal pools																										
34A. Upland/other **(03330)**																										
35A. Residential/other **(00200)**																										
36A. Industrial/other **(02500)**																3	1.379	Product	Gallons							
Totals	14	37.375	Product	Gallons		42	42.73	Product	Pounds		2	840	Product	Pounds		3	1.379	Product	Gallons		4	0.991	Product	Pounds		141

Table A36.

Application Sites:	Total Amount Used1518	Total Amount Type1619	Total Amount Unit1620	MGK Pyrocide Fogging Concentrate 7396 Comments	VectoLex WSP # Treatments	Total Amount Used	Total Amount Type2	Total Amount Unit	VectoLex WSP Comments	Altosid Pellets # Treatments	Total Amount Used2	Total Amount Type3	Total Amount Unit2	Altosid Pellets Comments	Mosquito Larvicide GB1111 # Treatments	Total Amount Used3	Total Amount Type4	Total Amount Type Unit
1. Swimming pool **(00100)**										1	6.000	Product	Pounds		2	0.102	Product	Gallons
2. Ponds **(00385)**															1	0.030	Product	Gallons
3. Water trough **(00390)**																		
4. Retention basin **(00400)**																		
5. Manmade pond **(00480)**																		
6. Fish pond **(01096)**										1	15.000	Product	Pounds					
7. Dredge spoil pond **(01276)**																		
8. Permanent pond **(03240)**																		
9. Alfalfa **(00020)**	0.803	Product	Gallons															
10. Row crop **(00050)**																		
11. Contour pasture **(00435)**	3.859	Product	Pounds												4	35.000	Product	Gallons
12. Pasture ditch **(00440)**										1	0.150	Product	Pounds					
13. Flooded pasture **(00470)**	14.037	Product	Gallons							3	228.000	Product	Pounds					
14. Strip check pasture **(00495)**	1.99	Product	Gallons															
15. Sump (**00500)**																		
16. Tail water drain **(00505)**																		
17. Septic tank **(01038)**																		
18. Container **(01045)**																		
19. Tires **(01060)**																		
20. Waterline leak **(01288)**	0.003	Product	Gallons							1	0.003	Product	Pounds					
21. Electrical box **(01624)**																		
22. Catch basin **(01699)**					4	52	Product	Other	52 Pouches	2	0.330	Product	Pounds					
23. Valve box **(02460)**																		
24. Waste/sewer pond **(02480)**																		
25. Roadside ditch **(01705)**															1	5.000	Product	Gallons
26. Depression/swale **(03120)**	0.042	Product	Gallons		1	80	Product	Other	80 Pouches	2	2.400	Product	Pounds					
27. Duck Club/seasonal waterfowl habitat **(00700)**	46.559	Product	Gallons							2	99.000	Product	Pounds		2	15.000	Product	Gallons
28. Tidal marsh **(03130)**										7	179.500	Product	Pounds					
29. Reclaimed marsh **(03230)**																		
30A. Reclaimed marsh/other **(03231)**																		
31. Streams/creeks **(03440)**																		
32. Treehole **(03480)**	0.528	Product	Gallons															
33. Vernal pools																		
34A. Upland/other **(03330)**																		
35A. Residential/other **(00200)**																		
36A. Industrial/other **(02500)**																		
Totals	67.821	Product	Gallons		5	132	Product	Other	Pouches	20	530.383	Product	Pounds		10	55.132	Product	Gallons

Table A37. **Pesticide Application Data for Fall 2011 – SCMAD**

Application Sites:	Altosid Liquid SR5 - # Treatments	Total Amount Used4	Total Amount Type5	Total Amount Unit5	Altosid Liquid SR5 Comments	Altosid XR Extended Residual - # Treatments	Total Amount Used13	Total Amount Type14	Total Amount Unit14	Altosid XR Extended Residual Comments	Altosid SBG - # Treatments	Total Amount Used15	Total Amount Type16	Total Amount Unit16	Altosid SBG Comments	Pyrenone 25-5 - # Treatments	Total Amount Used29	Total Amount Type30	Total Amount Unit30	Pyrenone 25-5 Comments	FourStar 180 Bs/Bti - # Treatments	Total Amount Used35	Total Amount Type36	Total Amount Unit36
1. Swimming pool **(00100)**						14	13.840	Product	Pounds															
2. Ponds **(00385)**																								
3. Water trough **(00390)**																								
4. Retention basin **(00400)**																								
5. Manmade pond **(00480)**																								
6. Fish pond **(01096)**																								
7. Dredge spoil pond **(01276)**																								
8. Permanent pond **(03240)**																								
9. Alfalfa **(00020)**																								
10. Row crop **(00050)**																								
11. Contour pasture **(00435)**																								
12. Pasture ditch **(00440)**																								
13. Flooded pasture **(00470)**																								
14. Strip check pasture **(00495)**																								
15. Sump (**00500)**																								
16. Tail water drain **(00505)**																								
17. Septic tank **(01038)**																								
18. Container **(01045)**																								
19. Tires **(01060)**																								
20. Waterline leak **(01288)**																								
21. Electrical box **(01624)**																								
22. Catch basin **(01699)**																					1	0.0661	Product	Pounds
23. Valve box **(02460)**																								
24. Waste/sewer pond **(02480)**																								
25. Roadside ditch **(01705)**																								
26. Depression/swale **(03120)**																								
27. Duck Club/seasonal waterfowl habitat **(00700)**	33	135.625	Product	Gallons							2	1,316.00	Product	Pounds		12	10.156	Product	Gallons					
28. Tidal marsh **(03130)**																								
29. Reclaimed marsh **(03230)**																								
30A. Reclaimed marsh/other **(03231)**																								
31. Streams/creeks **(03440)**																								
32. Treehole **(03480)**																								
33. Vernal pools																								
34A. Upland/other **(03330)**																								
35A. Residential/other **(00200)**																								
36A. Industrial/other **(02500)**																								
Totals	33	135.625	Product	Gallons		14	13.84	Product	Pounds		2	1316	Product	Pounds		12	10.156	Product	Gallons		1	0.0661	Product	Pounds

Table A37.

Application Sites:	FourStar 180 Bs/Bti Comments	MGK Pyrocide Fogging Concentrate 7396 - # Treatments	Total Amount Used1518	Total Amount Type1619	Total Amount Unit1620	MGK Pyrocide Fogging Concentrate 7396 Comments	Altosid Pellets # Treatments	Total Amount Used2	Total Amount Type3	Total Amount Unit2	Altosid Pellets Comments	Mosquito Larvicide GB-1111 # Treatments	Total Amount Used3	Total Amount Type4	Total Amount Unit3	Mosquito Larvicide GB-1111 Comments
1. Swimming pool **(00100)**												1	0.119	Product	Gallons	
2. Ponds **(00385)**																
3. Water trough **(00390)**																
4. Retention basin **(00400)**																
5. Manmade pond **(00480)**																
6. Fish pond **(01096)**																
7. Dredge spoil pond **(01276)**																
8. Permanent pond **(03240)**																
9. Alfalfa **(00020)**																
10. Row crop **(00050)**																
11. Contour pasture **(00435)**																
12. Pasture ditch **(00440)**																
13. Flooded pasture **(00470)**		2	1.462	Product	Gallons											
14. Strip check pasture **(00495)**																
15. Sump (**00500)**							2	9.000	Product	Pounds						
16. Tail water drain **(00505)**																
17. Septic tank **(01038)**																
18. Container **(01045)**																
19. Tires **(01060)**																
20. Waterline leak **(01288)**																
21. Electrical box **(01624)**																
22. Catch basin **(01699)**																
23. Valve box **(02460)**																
24. Waste/sewer pond **(02480)**																
25. Roadside ditch **(01705)**												1	5.000	Product	Gallons	
26. Depression/swale **(03120)**		1	0.650	Product	Gallons											
27. Duck Club/seasonal waterfowl habitat **(00700)**		80	41.139	Product	Gallons											
28. Tidal marsh **(03130)**																
29. Reclaimed marsh **(03230)**																
30A. Reclaimed marsh/other **(03231)**																
31. Streams/creeks **(03440)**																
32. Treehole **(03480)**																
33. Vernal pools																
34A. Upland/other **(03330)**																
35A. Residential/other **(00200)**																
36A. Industrial/other **(02500)**																
Totals		83	43.251	Product	Gallons		2	9	Product	Pounds		2	5.119	Product	Gallons	

Table A38. **Pesticide Application Data for Winter 2012 – SCMAD**

Application Sites:	Agnique MMF - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Agnique MMF Comments	Altosid Liquid SR5 - # Treatments	Total Amount Used4	Total Amount Type5	Total Amount Unit5	Altosid Liquid SR5 Comments	Altosid XR Extended Residual - # Treatments	Total Amount Used13	Total Amount Type14	Total Amount Unit14	Altosid XR Extended Residual Comments	FourStar 180 Bs/Bti - # Treatments	Total Amount Used35	Total Amount Type36	Total Amount Unit36	FourStar 180 Bs/Bti Comments	VectoLex WSP # Treatments	Total Amount Used	Total Amount Type2	Total Amount Unit
1. Swimming pool **(00100)**	3	0.170	Product	Gallons							49	45.490	Product	Pounds		1	1.322	Product	Pounds		1	5	Product	Other
2. Ponds **(00385)**											1	0.240	Product	Pounds										
3. Water trough **(00390)**																								
4. Retention basin **(00400)**																								
5. Manmade pond **(00480)**											3	1.440	Product	Pounds										
6. Fish pond **(01096)**																								
7. Dredge spoil pond **(01276)**																								
8. Permanent pond **(03240)**																								
9. Alfalfa **(00020)**																								
10. Row crop **(00050)**																								
11. Contour pasture **(00435)**																								
12. Pasture ditch **(00440)**																								
13. Flooded pasture **(00470)**																								
14. Strip check pasture **(00495)**																								
15. Sump (**00500)**																								
16. Tail water drain **(00505)**																								
17. Septic tank **(01038)**																								
18. Container **(01045)**																								
19. Tires **(01060)**																								
20. Waterline leak **(01288)**																								
21. Electrical box **(01624)**																								
22. Catch basin **(01699)**											22	30.960	Product	Pounds										
23. Valve box **(02460)**																								
24. Waste/sewer pond **(02480)**											1	1.760	Product	Pounds										
25. Roadside ditch **(01705)**																								
26. All Other Drains **(01702)**																								
26. Depression/swale **(03120)**																								
27. Duck Club/seasonal waterfowl habitat **(00700)**																								
28. Tidal marsh **(03130)**						5	23.125	Product	Gallons															
29. Reclaimed marsh **(03230)**																								
30A. Reclaimed marsh/other **(03231)**																								
31. Streams/creeks **(03440)**																								
32. Treehole **(03480)**																								
33. Vernal pools																								
34A. Upland/other **(03330)**																								
35A. Residential/other **(00200)**																								
36A. Industrial/other **(02500)**																								
Totals	3	0.17	Product	Gallons		5	23.125	Product	Gallons		76	79.89	Product	Pounds		1	1.322	Product	Pounds		1	5	Product	Other

Table A38.

Application Sites:	VectoLex WSP Comments	Altosid Pellets # Treatments	Total Amount Used2	Total Amount Type3	Total Amount Unit2	Altosid Pellets Comments	Mosquito Larvicide GB-1111 # Treatments	Total Amount Used3	Total Amount Type4	Total Amount Unit3	Mosquito Larvicide GB-1111 Comments
1. Swimming pool **(00100)**	Pouches						1	0.090	Product	Gallons	
2. Ponds **(00385)**		3	9.810	Product	Pounds						
3. Water trough **(00390)**											
4. Retention basin **(00400)**											
5. Manmade pond **(00480)**											
6. Fish pond **(01096)**											
7. Dredge spoil pond **(01276)**											
8. Permanent pond **(03240)**											
9. Alfalfa **(00020)**											
10. Row crop **(00050)**											
11. Contour pasture **(00435)**											
12. Pasture ditch **(00440)**		1	6.000	Product	Pounds						
13. Flooded pasture **(00470)**											
14. Strip check pasture **(00495)**											
15. Sump (**00500)**											
16. Tail water drain **(00505)**											
17. Septic tank **(01038)**											
18. Container **(01045)**											
19. Tires **(01060)**											
20. Waterline leak **(01288)**											
21. Electrical box **(01624)**											
22. Catch basin **(01699)**											
23. Valve box **(02460)**											
24. Waste/sewer pond **(02480)**											
25. Roadside ditch **(01705)**											
26. All Other Drains **(01702)**		3	1.003	Product	Pounds						
26. Depression/swale **(03120)**		4	60.000	Product	Pounds						
27. Duck Club/seasonal waterfowl habitat **(00700)**											
28. Tidal marsh **(03130)**		8	199.000	Product	Pounds						
29. Reclaimed marsh **(03230)**		1	15.000	Product	Pounds						
30A. Reclaimed marsh/other **(03231)**											
31. Streams/creeks **(03440)**		1	0.041	Product	Pounds						
32. Treehole **(03480)**											
33. Vernal pools											
34A. Upland/other **(03330)**											
35A. Residential/other **(00200)**											
36A. Industrial/other **(02500)**											
Totals	Pouches	21	290.854	Product	Pounds		1	0.09	Product	Gallons	

Table A39. **Pesticide Application Data for Spring 2012 – SCMAD**

Application Sites:	Agnique MMF - # Treatments	Total Amount Used	Total Amount Type	Total Amount Unit	Agnique MMF Comments	Altosid Liquid SR5 - # Treatments	Total Amount Used4	Total Amount Type5	Total Amount Unit5	Altosid Liquid SR5 Comments	Altosid XR Extended Residual - # Treatments	Total Amount Used13	Total Amount Type14	Total Amount Unit14	Altosid XR Extended Residual Comments	Scourge 18%+12% - # Treatments	Total Amount Used25	Total Amount Type26	Total Amount Unit26	Scourge 18%+12% Comments	FourStar 180 Bs/Bti - # Treatments	Total Amount Used35	Total Amount Type36	Total Amount Unit36
1. Swimming pool **(00100)**	1	0.010	Product	Gallons							60	61.050	Product	Pounds							1	1.322	Product	Pounds
2. Ponds **(00385)**	2	0.001	Product	Gallons							4	0.480	Product	Pounds										
3. Water trough **(00390)**																								
4. Retention basin **(00400)**																								
5. Manmade pond **(00480)**																								
6. Fish pond **(01096)**																								
7. Dredge spoil pond **(01276)**						2																		
8. Permanent pond **(03240)**																								
9. Alfalfa **(00020)**																								
10. Row crop **(00050)**																								
11. Contour pasture **(00435)**																								
12. Pasture ditch **(00440)**																								
13. Flooded pasture **(00470)**																								
14. Strip check pasture **(00495)**																								
15. Sump (**00500)**																								
16. Tail water drain **(00505)**																								
17. Septic tank **(01038)**																								
18. Container **(01045)**																								
19. Tires **(01060)**																								
20. Waterline leak **(01288)**																								
21. Electrical box **(01624)**																								
22. Catch basin **(01699)**											3	1.280	Product	Pounds										
23. Valve box **(02460)**																								
24. Waste/sewer pond **(02480)**											1	2.400	Product	Pounds										
25. Roadside ditch **(01705)**	1	0.001	Product	Gallons																				
26. All Other Drains **(01702)**																								
26. Depression/swale **(03120)**						2	0.593	Product	Gallons		1	1.680	Product	Pounds										
27. Duck Club/seasonal waterfowl habitat **(00700)**						1	4.687	Product	Gallons		1	3.200	Product	Pounds										
28. Tidal marsh **(03130)**						5	35.468	Product	Gallons															
29 A. Upland within vicinity of Tidal Marsh **(03131)**																								
30.A Residential within vicinity of Tidal Marsh **(03132)**																								
31 A. Industrial within vicinity of Tidal Marsh **(02500)**																								
32. Reclaimed marsh **(03230)**						10	3.062	Product	Gallons															
33A. Residential within vicinity of Reclaimed marsh **(03231)**																2	0.976	Product	Gallons					
34 A.Upland within vicinity of Reclaimed marsh **(03232)**																								
35.A. Residential/other **(02200)**																								
35. Streams/creeks **(03440)**																								
36. Treehole **(03480)**																2	0.585	Product	Gallons					
Totals	4	0.012	Product	Gallons		20	43.81	Product	Gallons		70	70.09	Product	Pounds		4	1.561	Product	Gallons		1	1.322	Product	Pounds

Table A39.

Application Sites:	FourStar 180 Bs/Bti Comments	Biomist 4+12 ULV - # Treatments	Total Amount Used22	Total Amount Type33	Total Amount Unit35	Biomist 4+12 ULV Comments	MGK Pyrocide Fogging Concentrate 7396 - # Treatments	Total Amount Used1518	Total Amount Type1619	Total Amount Unit1620	MGK Pyrocide Fogging Concentrate 7396 Comments	VectoLex WSP # Treatments	Total Amount Used	Total Amount Type2	Total Amount Unit	VectoLex WSP Comments	Altosid Pellets # Treatments	Total Amount Used2	Total Amount Type3	Total Amount Unit2	Altosid Pellets Comments	Mosquito Larvicide GB-1111 # Treatments	Total Amount Used3	Total Amount Type4	Total Amount Unit3
1. Swimming pool **(00100)**												1	5	Product	Other	Pouches						2	0.001	Product	Gallons
2. Ponds **(00385)**																	3	9.810	Product	Pounds					
3. Water trough **(00390)**																									
4. Retention basin **(00400)**																									
5. Manmade pond **(00480)**																									
6. Fish pond **(01096)**																									
7. Dredge spoil pond **(01276)**																									
8. Permanent pond **(03240)**																									
9. Alfalfa **(00020)**																									
10. Row crop **(00050)**																									
11. Contour pasture **(00435)**							5	2.559	Product	Gallons												1	10.000	Product	Gallons
12. Pasture ditch **(00440)**																	1	6.000	Product	Pounds					
13. Flooded pasture **(00470)**							9	1.669	Product	Gallons															
14. Strip check pasture **(00495)**							11	5.118	Product	Gallons															
15. Sump (**00500)**							2	0.771	Product	Gallons															
16. Tail water drain **(00505)**																									
17. Septic tank **(01038)**																									
18. Container **(01045)**																									
19. Tires **(01060)**																									
20. Waterline leak **(01288)**																									
21. Electrical box **(01624)**																									
22. Catch basin **(01699)**							1	0.126	Product	Gallons															
23. Valve box **(02460)**																									
24. Waste/sewer pond **(02480)**																						5	4.750	Product	Gallons
25. Roadside ditch **(01705)**																						1	0.500	Product	Gallons
26. All Other Drains **(01702)**																	3	1.003	Product	Pounds					
26. Depression/swale **(03120)**							5	0.694	Product	Gallons							4	60.000	Product	Pounds					
27. Duck Club/seasonal waterfowl habitat **(00700)**																									
28. Tidal marsh **(03130)**																	8	199.000	Product	Pounds					
29 A. Upland within vicinity of Tidal Marsh **(03131)**																									
30.A Residential within vicinity of Tidal Marsh **(03132)**		1	0.004	Product	Gallons		3	0.880	Product	Gallons															
31 A. Industrial within vicinity of Tidal Marsh **(02500)**							1	0.334	Product	Gallons															
32. Reclaimed marsh **(03230)**																	1	15.000	Product	Pounds					
33A. Residential within vicinity of Reclaimed marsh **(03231)**																									
34 A.Upland within vicinity of Reclaimed marsh **(03232)**							13	7.518	Product	Gallons															
35.A. Residential/other **(02200)**							2	0.023	Product	Gallons															
35. Streams/creeks **(03440)**																	1	0.041	Product	Pounds					
36. Treehole **(03480)**																									
Totals		1	0.004	Product	Gallons		52	19.692	Product	Gallons		1	5	Product	Other	Pouches	21	290.854	Product	Pounds		9	15.251	Product	Gallons

Table A40. Pesticide Product Key – SCMAD

Product	AI	Vector
Agnique MMF	Biodegradable Alcohol Ethoxylated Surfactant	Mosquito
Altosid Liquid SR5	Methoprene	Mosquito
Altosid Pellets	Methoprene	Mosquito
Altosid SBG Single Brood Granule	Methoprene	Mosquito
Altosid XR Extended Residual	Methoprene	Mosquito
Bayer Pyrenone 25-5 Public Health Insecticide	Pyrethrins and Piperonyl Butoxide	Mosquito
Clarke Biomist 4 + 12 ULV	Permethrin and Piperonyl Butoxide	Mosquito
FourStar 180 Bs/Bti	Bacillus Sphaericus and Bacillus Thuringiensis Israelensis	Mosquito
MGK Pyrocide Mosquito Adulticiding Concentrate for ULV Fogging 7396	Pyrethrins and Piperonyl Butoxide	Mosquito
Scourge 18% + 12%*	Resmethrin and Piperonyl Butoxide	Mosquito
VectoLex WSP Bs	Bacillus Sphaericus	Mosquito
GB-1111	Aliphatic Petroleum Hydrocarbons	Mosquito

Table A41. Pesticide Application Data for Summer 2011 – SMCMVCD

Application Sites:	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit18	BVA-2 Comments	VectoLex CG - # Treatments	Total Amount Used19	Total Amount Type20	Total Amount Unit20	VectoLex CG Comments	Astro, Ortho, Bonide, Tengard, etc. Products - # Treatments	Total Amount Used23	Total Amount Type24	Total Amount Unit24	Astro, Ortho, Bonide, Tengard, etc. Products Commnets	Delta Dust - # Treatments	Total Amount Used31	Total Amount Type32	Total Amount Unit32
Aerial yellowjacket nest																			
Bird Bath	7	1.75	Product			2	0.5	Product	Ounces (weight)										
Catch Basin	675	214012	Product	Ounces (volume)		5	1.25	Product	Ounces (weight)										
Creek	9	159.75	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Culvert	5	3.5	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Ditch	36	3318.5	Product	Ounces (volume)		5	5.25	Product	Ounces (weight)										
Drain Line	12	37	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Drain Pipes	4	500.75	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Fish Pond	325	154	Product	Ounces (volume)		42	15	Product	Ounces (weight)										
Fountain	142	50.75	Product	Ounces (volume)		23	5.75	Product	Ounces (weight)										
Fresh H2O Marsh	0	0	Product	Ounces (volume)		4	47680	Product	Ounces (weight)										
Ground yellowjacket nest			Product	Ounces (volume)		0	0	Product	Ounces (weight)		4	67.5	Product	Ounces (volume)		263	224.75	Product	Ounces (weight)
H20 under Bldg	22	1401.75	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Horse Trough	1	0.25	Product	Ounces (volume)		3	0.75	Product	Ounces (weight)										
Hot tub	20	7.25	Product	Ounces (volume)		2	0.5	Product	Ounces (weight)										
Imp H2O	44	133.5	Product	Ounces (volume)		2	5.25	Product	Ounces (weight)										
Misc container	43	13.75	Product	Ounces (volume)		6	1.5	Product	Ounces (weight)										
Multiple			Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Pond (natural)	5	2.25	Product	Ounces (volume)		2	0.5	Product	Ounces (weight)										
Pothole	2	10.25	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Reservoir	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Salt Marsh	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Seepage	4	2.25	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Septic Seepage	1	10	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Septic Tank	4	2.5	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Sewage Treatment Plant	35	17572	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Slough	2	1600	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Spring	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Storm Drain	1	0.25	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Street Gutter	22	238.5	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Sump	39	13.5	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Swim Pool	32	115.5	Product	Ounces (volume)		3	8	Product	Ounces (weight)										
Swim pool cover	2	1.5	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Swim Pool Drain	1	0.25	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Tank	3	20.75	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Tire	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Treehole	1	0.25	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Vault	16	163	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Water meter box	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)										
Waterfall	22	9.25	Product	Ounces (volume)		2	0.5	Product	Ounces (weight)										
Well	2	0.5	Product	Ounces (volume)		1	0.25	Product	Ounces (weight)										
Total	1539	239557	Product	Ounces (volume)		102	47725	Product	Ounces (weight)		4	67.5	Product	Ounces (volume)		263	224.75	Product	Ounces (weight)

Table A41.

Application Sites:	Delta Dust Comments	Wasp Freeze - # Treatments	Total Amount Used33	Total Amount Type34	Total Amount Unit34	Wasp Freeze Comments	Drione - # Treatments	Total Amount Used1112	Total Amount Type1213	Total Amount Unit1214	Drione Comments	VectoLex WDG - # Treatments	Total Amount Used3345	Total Amount Type3446	Total Amount Unit3447	VectoLex WDG Comments	Spectracide - # Treatments	Total Amount Used33452
Aerial yellowjacket nest		1	0.5	Product	Other (specify in comments section)	per can											2	7.5
Bird Bath												0	0					
Catch Basin												0	0					
Creek												0	0					
Culvert												0	0					
Ditch												0	0					
Drain Line												4	368	Product	Ounces (weight)			
Drain Pipes												0	0					
Fish Pond												0	0					
Fountain												0	0					
Fresh H2O Marsh												0	0					
Ground yellowjacket nest		4	3	Product	Other (specify in comments section)	per can	4	1.75	Product	Ounces (weight)		0	0				93	1545
H20 under Bldg												0	0					
Horse Trough												0	0					
Hot tub												0	0					
Imp H2O												0	0					
Misc container												0	0					
Multiple												0	0					
Pond (natural)												0	0					
Pothole												0	0					
Reservoir												0	0					
Salt Marsh												0	0					
Seepage												0	0					
Septic Seepage												0	0					
Septic Tank												0	0					
Sewage Treatment Plant												0	0					
Slough												0	0					
Spring												0	0					
Storm Drain												0	0					
Street Gutter												0	0					
Sump												0	0					
Swim Pool												0	0					
Swim pool cover												0	0					
Swim Pool Drain												0	0					
Tank												0	0					
Tire												0	0					
Treehole												0	0					
Vault												0	0					
Water meter box												0	0					
Waterfall												0	0					
Well												0	0					
Total		5	3.5	Product	Other (specify in comments section)	per can	4	1.75	Product	Ounces (weight)		4	368	Product	Ounces (weight)		95	1552.5

Table A41.

Application Sites:	Total Amount Type34463	Total Amount Unit34474	Spectracide Comments	Larvicide GB-1111 - # Treatments	Total Amount Used611	Total Amount Type712	Total Amount Unit713	Larvicide GB-1111 Comments	Natular G30 - # Treatments	Total Amount Used1317	Total Amount Type1418	Total Amount Unit1419	Natular G30 Comments	Spectracide Pro # Treatments	Total Amount Used1723	Total Amount Type1824	Total Amount Unit1825	Spectracide Pro Comments	Teknar SC - # Treatments
Aerial yellowjacket nest	Product	Ounces (volume)																	
Bird Bath				0	0	Product	Ounces (volume)		3	0.75	Product	Ounces (weight)							
Catch Basin				4	1	Product	Ounces (volume)		96	80.5	Product	Ounces (weight)							
Creek				1	1.5	Product	Ounces (volume)		47	2439.75	Product	Ounces (weight)							
Culvert				0	0	Product	Ounces (volume)		1	0.25	Product	Ounces (weight)							
Ditch				3	6.5	Product	Ounces (volume)		27	27.75	Product	Ounces (weight)							
Drain Line				1	0.25	Product	Ounces (volume)		3	1	Product	Ounces (weight)							
Drain Pipes				0	0	Product	Ounces (volume)		1	0.25	Product	Ounces (weight)							
Fish Pond				4	1	Product	Ounces (volume)		40	10	Product	Ounces (weight)							
Fountain				2	0.5	Product	Ounces (volume)		32	11.75	Product	Ounces (weight)							
Fresh H2O Marsh				0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)							
Ground yellowjacket nest	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)		63	1436.25	Product	Ounces (volume)		
H20 under Bldg				0	0	Product	Ounces (volume)		1	0.25	Product	Ounces (weight)							
Horse Trough				1	0.25	Product	Ounces (volume)		0	0	Product	Ounces (weight)							
Hot tub				0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)							
Imp H2O				2	50.25	Product	Ounces (volume)		26	369.5	Product	Ounces (weight)							1
Misc container				0	0	Product	Ounces (volume)		23	6	Product	Ounces (weight)							
Multiple				0	0	Product	Ounces (volume)		2	0.5	Product	Ounces (weight)							
Pond (natural)				0	0	Product	Ounces (volume)		1	0.25	Product	Ounces (weight)							
Pothole				0	0	Product	Ounces (volume)		1	0.25	Product	Ounces (weight)							
Reservoir				0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)							
Salt Marsh				0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)							
Seepage				0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)							
Septic Seepage				0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)							
Septic Tank				0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)							
Sewage Treatment Plant				0	0	Product	Ounces (volume)		1	0.25	Product	Ounces (weight)							
Slough				0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)							
Spring				0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)							
Storm Drain				0	0	Product	Ounces (volume)		1	0.25	Product	Ounces (weight)							
Street Gutter				0	0	Product	Ounces (volume)		39	10.25	Product	Ounces (weight)							
Sump				0	0	Product	Ounces (volume)		34	8.5	Product	Ounces (weight)							
Swim Pool				0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)							
Swim pool cover				0	0	Product	Ounces (volume)		1	0.25	Product	Ounces (weight)							
Swim Pool Drain				0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)							
Tank				0	0	Product	Ounces (volume)		1	4	Product	Ounces (weight)							
Tire				1	0.25	Product	Ounces (volume)		0	0	Product	Ounces (weight)							
Treehole				0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)							
Vault				0	0	Product	Ounces (volume)		42	12	Product	Ounces (weight)							
Water meter box				0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)							
Waterfall				0	0	Product	Ounces (volume)		12	3	Product	Ounces (weight)							
Well				0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)							
Total	Product	Ounces (volume)		19	61.5	Product	Ounces (volume)		435	2987.25	Product	Ounces (weight)		63	1436.25	Product	Ounces (volume)		1

Table A41.

Application Sites:	Total Amount Used3144	Total Amount Type3245	Total Amount Unit3246	Teknar SC Comments	Altosid Briquets - # Treatments	Total Amount Used4663	Total Amount Type5764	Total Amount Unit5865	Atlosid Briquets Comments	Altosid Liquid Concentrate - # Treatments	Total Amount Used6966	Total Amount Type71067	Total Amount Unit71168	Altosid Liquid Concentrate Comments	Altosid Pellets - # Treatments	Total Amount Used111269
Aerial yellowjacket nest																
Bird Bath					16	16	Product	her (specify in comments sect	per briq						2	0.5
Catch Basin					381	880	Product	her (specify in comments section)							42	584.75
Creek					5	127	Product	her (specify in comments section)							11	44.25
Culvert					4	7	Product	her (specify in comments section)							0	0
Ditch					14	31	Product	her (specify in comments section)							27	12
Drain Line					8	18	Product	her (specify in comments section)							3	0.75
Drain Pipes					0	0	Product	her (specify in comments section)							0	0
Fish Pond					624	942	Product	her (specify in comments section)							7	2
Fountain					375	598	Product	her (specify in comments section)							7	4.25
Fresh H2O Marsh					0	0	Product	her (specify in comments section)							0	0
Ground yellowjacket nest					0	0	Product	her (specify in comments section)								
H20 under Bldg					5	22	Product	her (specify in comments section)							1	2
Horse Trough					6	30	Product	her (specify in comments section)							0	0
Hot tub					26	27	Product	her (specify in comments section)							0	0
Imp H2O	8	Product	Ounces (volume)	Our product was Teknar HPD	34	57	Product	her (specify in comments section)		1	1	Product	Ounces (volume)	5%	20	5.25
Misc container					93	147	Product	her (specify in comments section)							8	6.75
Multiple							Product	her (specify in comments section)							0	0
Pond (natural)					10	24	Product	her (specify in comments section)							0	0
Pothole					0	0	Product	her (specify in comments section)							0	0
Reservoir					0	0	Product	her (specify in comments section)							0	0
Salt Marsh					0	0	Product	her (specify in comments section)							2	200
Seepage					0	0	Product	her (specify in comments section)							1	0.25
Septic Seepage					0	0	Product	her (specify in comments section)							0	0
Septic Tank					2	8	Product	her (specify in comments section)							0	0
Sewage Treatment Plant					1	1	Product	her (specify in comments section)							0	0
Slough					0	0	Product	her (specify in comments section)							0	0
Spring					0	0	Product	her (specify in comments section)							0	0
Storm Drain					1	1	Product	her (specify in comments section)							0	0
Street Gutter					1	1	Product	her (specify in comments section)							15	3.75
Sump					94	128	Product	her (specify in comments section)							5	1.25
Swim Pool					34	130	Product	her (specify in comments section)							2	0.5
Swim pool cover					0	0	Product	her (specify in comments section)							0	0
Swim Pool Drain					2	3	Product	her (specify in comments section)							0	0
Tank					10	31	Product	her (specify in comments section)							1	10
Tire					0	0	Product	her (specify in comments section)							1	0.25
Treehole					0	0	Product	her (specify in comments section)							7	1.75
Vault					66	161	Product	her (specify in comments section)							0	0
Water meter box					1	1	Product	her (specify in comments section)							0	0
Waterfall					40	89	Product	her (specify in comments section)							0	0
Well					12	16	Product	her (specify in comments section)							0	0
Total	8	Product	Ounces (volume)		1865	3496	Product	her (specify in comments sect	per briq	1	1	Product	Ounces (volume)		162	880.25

Table A41.

Application Sites:	Total Amount Type121370	Total Amount Unit121471	Altosid Pellets Comments	Altosid XR Briquets - # Treatments	Total Amount Used151875	Total Amount Type161976	Total Amount Unit162077	Altosid XR Briquets Comments	Altosid XR-G - # Treatments	Total Amount Used172178	Total Amount Type182279	Total Amount Unit182380	Altosid XR-G Comments	Pyrenone 25-5 # Treatments	Total Amount Used6	Total Amount Type7	Total Amount Unit8
Aerial yellowjacket nest																	
Bird Bath				3	1.5	Product	Other (specify in comments section)		1	0.25	Product	Other (specify in comments section)		0	0		
Catch Basin				67	99	Product	Other (specify in comments section)		70	25.5	Product	Other (specify in comments section)		0	0		
Creek				0	0	Product	Other (specify in comments section)		39	927.25	Product	Other (specify in comments section)		0	0		
Culvert				1	1	Product	Other (specify in comments section)		6	1.75	Product	Other (specify in comments section)		0	0		
Ditch				16	17	Product	Other (specify in comments section)		171	1786.75	Product	Other (specify in comments section)		0	0		
Drain Line				4	9.5	Product	Other (specify in comments section)		8	2.25	Product	Other (specify in comments section)		0	0		
Drain Pipes				1	1	Product	Other (specify in comments section)		0	0	Product	Other (specify in comments section)		0	0		
Fish Pond				126	139	Product	Other (specify in comments section)		37	10.75	Product	Other (specify in comments section)		0	0		
Fountain				49	48	Product	Other (specify in comments section)		30	7.5	Product	Other (specify in comments section)		0	0		
Fresh H2O Marsh				0	0	Product	Other (specify in comments section)		9	70883	Product	Other (specify in comments section)		0	0		
Ground yellowjacket nest						Product	Other (specify in comments section)				Product	Other (specify in comments section)		0	0		
H20 under Bldg				6	17	Product	Other (specify in comments section)		1	20	Product	Other (specify in comments section)		6	12.5	Product	Ounces (volume)
Horse Trough				10	15.5	Product	Other (specify in comments section)		13	3.25	Product	Other (specify in comments section)		0	0		
Hot tub				7	5.5	Product	Other (specify in comments section)		5	1.25	Product	Other (specify in comments section)		0	0		
Imp H2O				5	6.5	Product	Other (specify in comments section)		61	350.75	Product	Other (specify in comments section)		0	0		
Misc container				15	12	Product	Other (specify in comments section)		40	11	Product	Other (specify in comments section)		0	0		
Multiple				0		Product	Other (specify in comments section)				Product	Other (specify in comments section)		0	0		
Pond (natural)				1	1	Product	Other (specify in comments section)		2	4	Product	Other (specify in comments section)		0	0		
Pothole				2	8	Product	Other (specify in comments section)		3	0.75	Product	Other (specify in comments section)		0	0		
Reservoir				0	0	Product	Other (specify in comments section)		2	20	Product	Other (specify in comments section)		0	0		
Salt Marsh				0	0	Product	Other (specify in comments section)		3	220	Product	Other (specify in comments section)		0	0		
Seepage				0	0	Product	Other (specify in comments section)		7	1.75	Product	Other (specify in comments section)		0	0		
Septic Seepage				1	4	Product	Other (specify in comments section)		0	0	Product	Other (specify in comments section)		0	0		
Septic Tank				2	4.5	Product	Other (specify in comments section)		0	0	Product	Other (specify in comments section)		0	0		
Sewage Treatment Plant				0	0	Product	Other (specify in comments section)		0	0	Product	Other (specify in comments section)		0	0		
Slough				0	0	Product	Other (specify in comments section)		1	40	Product	Other (specify in comments section)		0	0		
Spring				2	2.5	Product	Other (specify in comments section)		0	0	Product	Other (specify in comments section)		0	0		
Storm Drain				0	0	Product	Other (specify in comments section)		0	0	Product	Other (specify in comments section)		0	0		
Street Gutter				2	2	Product	Other (specify in comments section)		27	8	Product	Other (specify in comments section)		0	0		
Sump				20	20	Product	Other (specify in comments section)		15	3.75	Product	Other (specify in comments section)		0	0		
Swim Pool				14	42	Product	Other (specify in comments section)		2	1.25	Product	Other (specify in comments section)		0	0		
Swim pool cover				1	2	Product	Other (specify in comments section)		0	0	Product	Other (specify in comments section)		0	0		
Swim Pool Drain				0	0	Product	Other (specify in comments section)		0	0	Product	Other (specify in comments section)		0	0		
Tank				5	11	Product	Other (specify in comments section)		1	4	Product	Other (specify in comments section)		0	0		
Tire				0	0	Product	Other (specify in comments section)		1	0.25	Product	Other (specify in comments section)		0	0		
Treehole				1	0.5	Product	Other (specify in comments section)		0	0	Product	Other (specify in comments section)		0	0		
Vault				16	2505.5	Product	Other (specify in comments section)		31	9	Product	Other (specify in comments section)		0	0		
Water meter box				0	0	Product	Other (specify in comments section)		0	0	Product	Other (specify in comments section)		0	0		
Waterfall				7	15.5	Product	Other (specify in comments section)		7	1.75	Product	Other (specify in comments section)		0	0		
Well				3	3	Product	Other (specify in comments section)		1	0.25	Product	Other (specify in comments section)		0	0		
Total		0		387	2994	Product	Other (specify in comments section)		594	74346	Product	Other (specify in comments section)		6	12.5	Product	Ounces (volume)

Table A41.

Application Sites:	Pyrenone 25-5 Comments	VectoLex WSP - # Treatments	Total Amount Used16	Total Amount Type17	Total Amount Unit18	VectoLex WSP Comments
Aerial yellowjacket nest						
Bird Bath		0	0	Product	Other (specify in comments section)	per packet
Catch Basin		0	0	Product	Other (specify in comments section)	
Creek		0	0	Product	Other (specify in comments section)	
Culvert		0	0	Product	Other (specify in comments section)	
Ditch		1	1	Product	Other (specify in comments section)	
Drain Line		0	0	Product	Other (specify in comments section)	
Drain Pipes		0	0	Product	Other (specify in comments section)	
Fish Pond		6	8.25	Product	Other (specify in comments section)	
Fountain		1	1	Product	Other (specify in comments section)	
Fresh H2O Marsh		0	0	Product	Other (specify in comments section)	
Ground yellowjacket nest		0	0	Product	Other (specify in comments section)	
H20 under Bldg		0	0	Product	Other (specify in comments section)	
Horse Trough		1	1	Product	Other (specify in comments section)	
Hot tub		0	0	Product	Other (specify in comments section)	
Imp H2O		0	0	Product	Other (specify in comments section)	
Misc container		0	0	Product	Other (specify in comments section)	
Multiple		0	0	Product	Other (specify in comments section)	
Pond (natural)		0	0	Product	Other (specify in comments section)	
Pothole		0	0	Product	Other (specify in comments section)	
Reservoir		0	0	Product	Other (specify in comments section)	
Salt Marsh		0	0	Product	Other (specify in comments section)	
Seepage		0	0	Product	Other (specify in comments section)	
Septic Seepage		0	0	Product	Other (specify in comments section)	
Septic Tank		0	0	Product	Other (specify in comments section)	
Sewage Treatment Plant		0	0	Product	Other (specify in comments section)	
Slough		0	0	Product	Other (specify in comments section)	
Spring		1	1	Product	Other (specify in comments section)	
Storm Drain		0	0	Product	Other (specify in comments section)	
Street Gutter		0	0	Product	Other (specify in comments section)	
Sump		1	1	Product	Other (specify in comments section)	
Swim Pool		0	0	Product	Other (specify in comments section)	
Swim pool cover		0	0	Product	Other (specify in comments section)	
Swim Pool Drain		0	0	Product	Other (specify in comments section)	
Tank		1	1	Product	Other (specify in comments section)	
Tire		0	0	Product	Other (specify in comments section)	
Treehole		0	0	Product	Other (specify in comments section)	
Vault		1	5	Product	Other (specify in comments section)	
Water meter box		0	0	Product	Other (specify in comments section)	
Waterfall		0	0	Product	Other (specify in comments section)	
Well		0	0	Product	Other (specify in comments section)	
Total		13	19.25	Product	Other (specify in comments section)	per packet

Table A42. **Pesticide Application Data for Fall 2011 – SMCMVCD**

Application Sites:	Altosid Pellets WSP - # Treatments	Total Amount Used11	Total Amount Type12	Total Amount Unit12	Altosid Pellets WSP Comments	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit18	BVA-2 Comments	VectoLex CG - # Treatments	Total Amount Used19	Total Amount Type20	Total Amount Unit20	VectoLex CG Comments	Delta Dust - # Treatments	Total Amount Used31	Total Amount Type32
Aerial yellowjacket nest						0												
Bird Bath	0	0	Product	Other (specify in comments section)	packet	4	1	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Catch Basin	2	2		Other (specify in comments section)	packet	215	47661	Product	Ounces (volume)		1	0.25	Product	Ounces (weight)				
Creek	0	0		Other (specify in comments section)	packet	3	9.25	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Culvert	0	0		Other (specify in comments section)	packet	3	1.5	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Ditch	6	6		Other (specify in comments section)	packet	12	60	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Drain Line	0	0		Other (specify in comments section)	packet	5	20.75	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Drain Pipes	0	0		Other (specify in comments section)	packet	2	0.5	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Fish Pond	0	0		Other (specify in comments section)	packet	360	170.5	Product	Ounces (volume)		45	14.25	Product	Ounces (weight)				
Fountain	5	5		Other (specify in comments section)	packet	157	43.5	Product	Ounces (volume)		33	8.25	Product	Ounces (weight)				
Fresh H2O Marsh	0	0		Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Ground yellowjacket nest	0	0		Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)		26	18.25	Product
H20 under Bldg	0	0		Other (specify in comments section)	packet	31	905	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Horse Trough	1	6		Other (specify in comments section)	packet	2	0.5	Product	Ounces (volume)		6	1.5	Product	Ounces (weight)				
Hot tub	1	1		Other (specify in comments section)	packet	19	6.5	Product	Ounces (volume)		1	0.25	Product	Ounces (weight)				
Imp H2O	2	2		Other (specify in comments section)	packet	22	18.5	Product	Ounces (volume)		3	15.25	Product	Ounces (weight)				
Misc container	1	1		Other (specify in comments section)	packet	53	14.25	Product	Ounces (volume)		12	3	Product	Ounces (weight)				
Multiple	0	0		Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Pond (natural)	0	0		Other (specify in comments section)	packet	5	2	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Pothole	0	0		Other (specify in comments section)	packet	1	10	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Reservoir	0	0		Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Salt Marsh	0	0		Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Seepage	0	0		Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Septic Seepage	0	0		Other (specify in comments section)	packet	2	20	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Septic Tank	0	0		Other (specify in comments section)	packet	3	2	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Sewage Treatment Plant	0	0		Other (specify in comments section)	packet	13	7552	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Slough	0	0		Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Spring	0	0		Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Storm Drain	0	0		Other (specify in comments section)	packet	1	0.25	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Street Gutter	0	0		Other (specify in comments section)	packet	3	1.75	Product	Ounces (volume)		1	0.25	Product	Ounces (weight)				
Sump	0	0		Other (specify in comments section)	packet	27	9	Product	Ounces (volume)		1	0.25	Product	Ounces (weight)				
Swim Pool	1	1		Other (specify in comments section)	packet	33	103.25	Product	Ounces (volume)		2	2	Product	Ounces (weight)				
Swim pool cover	0	0		Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Swim Pool Drain	0	0		Other (specify in comments section)	packet	3	0.75	Product	Ounces (volume)		1	0.25	Product	Ounces (weight)				
Tank	0	0		Other (specify in comments section)	packet	2	2.25	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Tire	0	0		Other (specify in comments section)	packet	2	0.5	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Treehole	0	0		Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		1	0.25	Product	Ounces (weight)				
Vault	2	7		Other (specify in comments section)	packet	10	34.5	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Water meter box	0	0		Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Waterfall	0	0		Other (specify in comments section)	packet	22	7.75	Product	Ounces (volume)		4	1.5	Product	Ounces (weight)				
Well	0	0		Other (specify in comments section)	packet	4	1.25	Product	Ounces (volume)									
Paper Wasp Nest																		
Total	21	31	Product	Other (specify in comments section)	packet	1019	56660	Product	Ounces (volume)		111	47.25	Product	Ounces (weight)		26	18.25	Product

Table A42.

Application Sites:	Total Amount Unit32	Delta Dust Comments	VectoLex WDG - # Treatments	Total Amount Used3345	Total Amount Type3446	Total Amount Unit3447	VectoLex WDG Comments	Spectracide - # Treatments	Total Amount Used33452	Total Amount Type34463	Total Amount Unit34474	Spectracide Comments	Larvicide GB-1111 - # Treatments	Total Amount Used611	Total Amount Type712	Total Amount Unit713	Larvicide GB-1111 Comments	Natular G30 - # Treatments
Aerial yellowjacket nest																		
Bird Bath																		2
Catch Basin																		35
Creek																		2
Culvert																		4
Ditch																		12
Drain Line			3	160	Product	Ounces (weight)												6
Drain Pipes																		1
Fish Pond																		21
Fountain																		14
Fresh H2O Marsh																		0
Ground yellowjacket nest	Ounces (weight)							36	420	Product	Ounces (volume)							0
H20 under Bldg																		1
Horse Trough																		0
Hot tub																		0
Imp H2O																		25
Misc container																		25
Multiple																		0
Pond (natural)																		2
Pothole																		0
Reservoir																		0
Salt Marsh																		0
Seepage																		0
Septic Seepage																		0
Septic Tank																		0
Sewage Treatment Plant													2	178	Product	Ounces (volume)		0
Slough																		0
Spring																		0
Storm Drain																		0
Street Gutter																		16
Sump																		19
Swim Pool																		0
Swim pool cover																		0
Swim Pool Drain																		0
Tank																		1
Tire																		3
Treehole																		0
Vault																		24
Water meter box																		0
Waterfall																		5
Well																		0
Paper Wasp Nest								2	18.75	Product	Ounces (volume)							0
Total	Ounces (weight)		3	160	Product	Ounces (weight)		38	438.75	Product	Ounces (volume)		2	178	Product	Ounces (volume)		218

Table A42.

Application Sites:	Total Amount Used1317	Total Amount Type1418	Total Amount Unit1419	Natular G30 Comments	Spectracide Pro # Treatments	Total Amount Used1723	Total Amount Type1824	Total Amount Unit1825	Spectracide Pro Comments	Teknar SC - # Treatments	Total Amount Used3144	Total Amount Type3245	Total Amount Unit3246	Teknar SC Comments	Altosid Briquets - # Treatments	Total Amount Used4663	Total Amount Type5764
Aerial yellowjacket nest															0	0	Product
Bird Bath	0.5	Product	Ounces (weight)							0	0	Product	Ounces (volume)		22	22	Product
Catch Basin	12.5	Product	Ounces (weight)							0	0	Product	Ounces (volume)		321	722	Product
Creek	4.5	Product	Ounces (weight)							0	0	Product	Ounces (volume)		5	11	Product
Culvert	1	Product	Ounces (weight)							0	0	Product	Ounces (volume)		3	3	Product
Ditch	17.25	Product	Ounces (weight)							2	392	Product	Ounces (volume)		12	18	Product
Drain Line	1.75	Product	Ounces (weight)							0	0	Product	Ounces (volume)		11	20	Product
Drain Pipes	0.25	Product	Ounces (weight)							0	0	Product	Ounces (volume)		4	6	Product
Fish Pond	10.5	Product	Ounces (weight)							0	0	Product	Ounces (volume)		929	1335	Product
Fountain	3.5	Product	Ounces (weight)							0	0	Product	Ounces (volume)		529	828	Product
Fresh H2O Marsh	0	Product	Ounces (weight)							1	12	Product	Ounces (volume)		0	0	Product
Ground yellowjacket nest	0	Product	Ounces (weight)		11	277.5	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0	Product
H20 under Bldg	2	Product	Ounces (weight)							0	0	Product	Ounces (volume)		3	11	Product
Horse Trough	0	Product	Ounces (weight)							0	0	Product	Ounces (volume)		9	61	Product
Hot tub	0	Product	Ounces (weight)							0	0	Product	Ounces (volume)		46	47	Product
Imp H2O	10.75	Product	Ounces (weight)							2	33	Product	Ounces (volume)		32	37	Product
Misc container	6.25	Product	Ounces (weight)							0	0	Product	Ounces (volume)		146	246	Product
Multiple	0	Product	Ounces (weight)							0	0	Product	Ounces (volume)		0	0	Product
Pond (natural)	0.5	Product	Ounces (weight)							0	0	Product	Ounces (volume)		12	32	Product
Pothole	0	Product	Ounces (weight)							0	0	Product	Ounces (volume)		3	8	Product
Reservoir	0	Product	Ounces (weight)							0	0	Product	Ounces (volume)		1	1	Product
Salt Marsh	0	Product	Ounces (weight)							0	0	Product	Ounces (volume)		0	0	Product
Seepage	0	Product	Ounces (weight)							0	0	Product	Ounces (volume)		0	0	Product
Septic Seepage	0	Product	Ounces (weight)							0	0	Product	Ounces (volume)		0	0	Product
Septic Tank	0	Product	Ounces (weight)							0	0	Product	Ounces (volume)		1	4	Product
Sewage Treatment Plant	0	Product	Ounces (weight)							0	0	Product	Ounces (volume)		0	0	Product
Slough	0	Product	Ounces (weight)							0	0	Product	Ounces (volume)		0	0	Product
Spring	0	Product	Ounces (weight)							0	0	Product	Ounces (volume)		0	0	Product
Storm Drain	0	Product	Ounces (weight)							0	0	Product	Ounces (volume)		2	2	Product
Street Gutter	4.25	Product	Ounces (weight)							0	0	Product	Ounces (volume)		3	3	Product
Sump	4.75	Product	Ounces (weight)							0	0	Product	Ounces (volume)		114	145	Product
Swim Pool	0	Product	Ounces (weight)							0	0	Product	Ounces (volume)		63	232	Product
Swim pool cover	0	Product	Ounces (weight)							0	0	Product	Ounces (volume)		0	0	Product
Swim Pool Drain	0	Product	Ounces (weight)							0	0	Product	Ounces (volume)		6	7	Product
Tank	4	Product	Ounces (weight)							0	0	Product	Ounces (volume)		12	27	Product
Tire	0.75	Product	Ounces (weight)							0	0	Product	Ounces (volume)		2	2	Product
Treehole	0	Product	Ounces (weight)							0	0	Product	Ounces (volume)		4	4	Product
Vault	6.25	Product	Ounces (weight)							0	0	Product	Ounces (volume)		71	126	Product
Water meter box	0	Product	Ounces (weight)							0	0	Product	Ounces (volume)		1	1	Product
Waterfall	1.25	Product	Ounces (weight)							0	0	Product	Ounces (volume)		60	150	Product
Well	0	Product	Ounces (weight)							0	0	Product	Ounces (volume)		14	16	Product
Paper Wasp Nest	0	Product	Ounces (weight)							0	0	Product	Ounces (volume)		0	0	Product
Total	92.5	Product	Ounces (weight)		11	277.5	Product	Ounces (volume)		5	437	Product	Ounces (volume)		2441	4127	Product

Table A42.

Application Sites:	Total Amount Unit5865	Atlosid Briquets Comments	Altosid Pellets - # Treatments	Total Amount Used111269	Total Amount Type121370	Total Amount Unit121471	Altosid Pellets Comments	Altosid XR Briquets - # Treatments	Total Amount Used151875	Total Amount Type161976	Total Amount Unit162077	Altosid XR Briquets Comments	Altosid XR-G - # Treatments	Total Amount Used172178	Total Amount Type182279	Total Amount Unit182380
Aerial yellowjacket nest	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)
Bird Bath	Other (specify in comments section)	briquet	3	0.75	Product	Ounces (weight)		2	2.5	Product	Other (specify in comments section)	briquet	5	1.25	Product	Ounces (weight)
Catch Basin	Other (specify in comments section)	briquet	34	489.25	Product	Ounces (weight)		16	29	Product	Other (specify in comments section)	briquet	24	6	Product	Ounces (weight)
Creek	Other (specify in comments section)	briquet	4	1.5	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	4	22.75	Product	Ounces (weight)
Culvert	Other (specify in comments section)	briquet	1	0.25	Product	Ounces (weight)		1	1	Product	Other (specify in comments section)	briquet	5	1.25	Product	Ounces (weight)
Ditch	Other (specify in comments section)	briquet	24	80	Product	Ounces (weight)		1	7	Product	Other (specify in comments section)	briquet	59	668.25	Product	Ounces (weight)
Drain Line	Other (specify in comments section)	briquet	4	1	Product	Ounces (weight)		1	5	Product	Other (specify in comments section)	briquet	8	2.25	Product	Ounces (weight)
Drain Pipes	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)
Fish Pond	Other (specify in comments section)	briquet	22	5.5	Product	Ounces (weight)		81	111	Product	Other (specify in comments section)	briquet	70	19.25	Product	Ounces (weight)
Fountain	Other (specify in comments section)	briquet	13	3.25	Product	Ounces (weight)		31	54.5	Product	Other (specify in comments section)	briquet	71	17.75	Product	Ounces (weight)
Fresh H2O Marsh	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	5	35208	Product	Ounces (weight)
Ground yellowjacket nest	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)
H20 under Bldg	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)		5	13	Product	Other (specify in comments section)	briquet	1	0.25	Product	Ounces (weight)
Horse Trough	Other (specify in comments section)	briquet	1	0.25	Product	Ounces (weight)		9	20	Product	Other (specify in comments section)	briquet	7	1.75	Product	Ounces (weight)
Hot tub	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)		9	9	Product	Other (specify in comments section)	briquet	1	0.25	Product	Ounces (weight)
Imp H2O	Other (specify in comments section)	briquet	44	27	Product	Ounces (weight)		3	16	Product	Other (specify in comments section)	briquet	65	164.25	Product	Ounces (weight)
Misc container	Other (specify in comments section)	briquet	27	7.75	Product	Ounces (weight)		11	15	Product	Other (specify in comments section)	briquet	93	27.75	Product	Ounces (weight)
Multiple	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)
Pond (natural)	Other (specify in comments section)	briquet	1	0.25	Product	Ounces (weight)		2	6	Product	Other (specify in comments section)	briquet	3	0.75	Product	Ounces (weight)
Pothole	Other (specify in comments section)	briquet	1	0.5	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)
Reservoir	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	1	0.25	Product	Ounces (weight)
Salt Marsh	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)		1	1	Product	Other (specify in comments section)	briquet	7	784	Product	Ounces (weight)
Seepage	Other (specify in comments section)	briquet	1	0.25	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	4	1	Product	Ounces (weight)
Septic Seepage	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)		1	3	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)
Septic Tank	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)		2	3	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)
Sewage Treatment Plant	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)
Slough	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)
Spring	Other (specify in comments section)	briquet	2	0.75	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)
Storm Drain	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)
Street Gutter	Other (specify in comments section)	briquet	13	3.25	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	15	3.75	Product	Ounces (weight)
Sump	Other (specify in comments section)	briquet	4	1	Product	Ounces (weight)		7	7	Product	Other (specify in comments section)	briquet	29	7.5	Product	Ounces (weight)
Swim Pool	Other (specify in comments section)	briquet	3	0.75	Product	Ounces (weight)		12	30	Product	Other (specify in comments section)	briquet	3	1	Product	Ounces (weight)
Swim pool cover	Other (specify in comments section)	briquet	4	2	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	1	0.25	Product	Ounces (weight)
Swim Pool Drain	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)		2	2	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)
Tank	Other (specify in comments section)	briquet	1	1	Product	Ounces (weight)		2	4	Product	Other (specify in comments section)	briquet	1	4	Product	Ounces (weight)
Tire	Other (specify in comments section)	briquet	4	1	Product	Ounces (weight)		1	1	Product	Other (specify in comments section)	briquet	7	1.75	Product	Ounces (weight)
Treehole	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)		2	3	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)
Vault	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)		3	7	Product	Other (specify in comments section)	briquet	55	14.25	Product	Ounces (weight)
Water meter box	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)
Waterfall	Other (specify in comments section)	briquet	3	0.75	Product	Ounces (weight)		2	5	Product	Other (specify in comments section)	briquet	18	4.5	Product	Ounces (weight)
Well	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)		5	6	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)
Paper Wasp Nest	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)
Total	Other (specify in comments section)	briquet	214	628	Product	Ounces (weight)		212	361	Product	Other (specify in comments section)	briquet	562	36964	Product	Ounces (weight)

Table A42.

Application Sites:	Altosid XR-G Comments	Altosid Liquid (Not-conentrate) # Treatments	Total Amount Used	Total Amount Type2	Total Amount Unit	Altosid Liquid (not-concentrate) Comments	Pyrenone 25-5 # Treatments	Total Amount Used6	Total Amount Type7	Total Amount Unit8	Pyrenone 25-5 Comments	VectoLex WSP - # Treatments	Total Amount Used2	Total Amount Type17	Total Amount Unit18	VectoLex WSP Comments
Aerial yellowjacket nest		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Bird Bath		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Catch Basin		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Creek		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Culvert		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Ditch		2	40	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Drain Line		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Drain Pipes		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Fish Pond		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		1	1	Product	Other (specify in comments section)	packet
Fountain		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Fresh H2O Marsh		1	3	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Ground yellowjacket nest		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
H20 under Bldg		0	0	Product	Ounces (volume)		7	69.25	Product	Ounces (volume)		0	0			
Horse Trough		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Hot tub		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Imp H2O		2	2.25	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Misc container		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Multiple		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Pond (natural)		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Pothole		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Reservoir		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Salt Marsh		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Seepage		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Septic Seepage		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Septic Tank		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Sewage Treatment Plant		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Slough		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Spring		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Storm Drain		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Street Gutter		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Sump		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Swim Pool		1	5	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Swim pool cover		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Swim Pool Drain		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Tank		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Tire		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Treehole		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Vault		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Water meter box		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Waterfall		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Well		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Paper Wasp Nest		0	0	Product	Ounces (volume)		0	0	Product	Ounces (volume)		0	0			
Total		6	50.25	Product	Ounces (volume)		7	69.25	Product	Ounces (volume)		1	1	Product	Other (specify in comments section)	packet

Table A43. Pesticide Application Data for Winter 2012 – SMCMVCD

Application Sites:	Altosid Pellets WSP - # Treatments	Total Amount Used11	Total Amount Type12	Total Amount Unit12	Altosid Pellets WSP Comments	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit18	BVA-2 Comments	VectoLex CG - # Treatments	Total Amount Used19	Total Amount Type20	Total Amount Unit20	VectoLex CG Comments	Delta Dust - # Treatments	Total Amount Used31	Total Amount Type32
Bird Bath	0	0	Product	Other (specify in comments section)	packet	1	0.25	Product	Ounces (volume)		2	0.5	Product	Ounces (weight)				
Catch Basin	24	32	Product	Other (specify in comments section)	packet	45	104.75	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Creek	0	0	Product	Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Culvert	0	0	Product	Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Ditch	4	8	Product	Other (specify in comments section)	packet	7	3208	Product	Ounces (volume)		6	5	Product	Ounces (weight)				
Drain Line	0	0	Product	Other (specify in comments section)	packet	5	150.25	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Drain Pipes	0	0	Product	Other (specify in comments section)	packet	1	0.25	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Fish Pond	12	15	Product	Other (specify in comments section)	packet	279	130	Product	Ounces (volume)		63	17.25	Product	Ounces (weight)				
Fountain	20	24	Product	Other (specify in comments section)	packet	103	29.75	Product	Ounces (volume)		39	9.75	Product	Ounces (weight)				
Fresh H2O Marsh	1	2	Product	Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Ground yellowjacket nest	0	0	Product	Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)		1	0.5	Product
H20 under Bldg	0	0	Product	Other (specify in comments section)	packet	20	935.75	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Horse Trough	0	0	Product	Other (specify in comments section)	packet	2	0.75	Product	Ounces (volume)		6	1.5	Product	Ounces (weight)				
Hot tub	1	1	Product	Other (specify in comments section)	packet	11	3.75	Product	Ounces (volume)		1	0.25	Product	Ounces (weight)				
Imp H2O	10	24	Product	Other (specify in comments section)	packet	23	36	Product	Ounces (volume)		4	17.25	Product	Ounces (weight)				
Misc container	5	7	Product	Other (specify in comments section)	packet	47	12.25	Product	Ounces (volume)		12	3	Product	Ounces (weight)				
Multiple	0	0	Product	Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Paper Wasp Nest	0	0	Product	Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Pond (natural)	0	0	Product	Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Pothole	1	1	Product	Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Reservoir	0	0	Product	Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Salt Marsh	0	0	Product	Other (specify in comments section)	packet	1	3200	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Seepage	0	0	Product	Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Septic Seepage	0	0	Product	Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Septic Tank	0	0	Product	Other (specify in comments section)	packet	4	2.5	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Sewage Treatment Plant	0	0	Product	Other (specify in comments section)	packet	11	4242	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Spring	0	0	Product	Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Storm Drain	0	0	Product	Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Street Gutter	0	0	Product	Other (specify in comments section)	packet	4	1.25	Product	Ounces (volume)		1	0.25	Product	Ounces (weight)				
Sump	8	8	Product	Other (specify in comments section)	packet	15	3.75	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Swim Pool	1	2	Product	Other (specify in comments section)	packet	29	100.25	Product	Ounces (volume)		2	7.5	Product	Ounces (weight)				
Swim pool cover	0	0	Product	Other (specify in comments section)	packet	4	6	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Swim Pool Drain	0	0	Product	Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Tank	0	0	Product	Other (specify in comments section)	packet	4	21.75	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Tire	0	0	Product	Other (specify in comments section)	packet	3	15.75	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Treehole	1	1	Product	Other (specify in comments section)	packet	1	0.25	Product	Ounces (volume)		3	0.75	Product	Ounces (weight)				
Vault	7	14	Product	Other (specify in comments section)	packet	1	2.5	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Water meter box	0	0	Product	Other (specify in comments section)	packet	0	0	Product	Ounces (volume)		0	0	Product	Ounces (weight)				
Waterfall	1	3	Product	Other (specify in comments section)	packet	15	4.5	Product	Ounces (volume)		4	1.25	Product	Ounces (weight)				
Well	1	1	Product	Other (specify in comments section)	packet	4	3	Product	Ounces (volume)		2	0.5	Product	Ounces (weight)				
Total	97	143	Product	Other (specify in comments section)	packet	640	12215.25	Product	Ounces (volume)		145	64.75	Product	Ounces (weight)		1	0.5	Product

Table A43.

Application Sites:	Total Amount Unit32	Delta Dust Comments	VectoLex WDG - # Treatments	Total Amount Used3345	Total Amount Type3446	Total Amount Unit3447	VectoLex WDG Comments	Spectracide - # Treatments	Total Amount Used33452	Total Amount Type34463	Total Amount Unit34474	Spectracide Comments	Natular G30 - # Treatments	Total Amount Used1317	Total Amount Type1418	Total Amount Unit1419	Natular G30 Comments	Teknar SC - # Treatments
Bird Bath													0	0	Product	Ounces (weight)		0
Catch Basin													6	1.5	Product	Ounces (weight)		0
Creek													0	0	Product	Ounces (weight)		0
Culvert													2	0.5	Product	Ounces (weight)		0
Ditch													5	203.75	Product	Ounces (weight)		3
Drain Line			2	156	Product	Ounces (weight)							0	0	Product	Ounces (weight)		0
Drain Pipes													1	0.25	Product	Ounces (weight)		0
Fish Pond													3	1	Product	Ounces (weight)		0
Fountain													2	0.5	Product	Ounces (weight)		0
Fresh H2O Marsh													1	25	Product	Ounces (weight)		0
Ground yellowjacket nest	Ounces (weight)							3	22.5	Product	Ounces (volume)		0	0	Product	Ounces (weight)		0
H20 under Bldg													0	0	Product	Ounces (weight)		0
Horse Trough													0	0	Product	Ounces (weight)		0
Hot tub													0	0	Product	Ounces (weight)		0
Imp H2O													22	31.25	Product	Ounces (weight)		17
Misc container													5	1.25	Product	Ounces (weight)		0
Multiple													0	0	Product	Ounces (weight)		0
Paper Wasp Nest								2	7.5	Product	Ounces (volume)		0	0	Product	Ounces (weight)		0
Pond (natural)													0	0	Product	Ounces (weight)		1
Pothole													0	0	Product	Ounces (weight)		0
Reservoir													0	0	Product	Ounces (weight)		0
Salt Marsh													1	1	Product	Ounces (weight)		1
Seepage													0	0	Product	Ounces (weight)		0
Septic Seepage													0	0	Product	Ounces (weight)		0
Septic Tank													0	0	Product	Ounces (weight)		0
Sewage Treatment Plant													0	0	Product	Ounces (weight)		0
Spring													0	0	Product	Ounces (weight)		0
Storm Drain													0	0	Product	Ounces (weight)		0
Street Gutter													1	0.25	Product	Ounces (weight)		0
Sump													1	0.25	Product	Ounces (weight)		0
Swim Pool													2	0.75	Product	Ounces (weight)		0
Swim pool cover													1	1	Product	Ounces (weight)		0
Swim Pool Drain													0	0	Product	Ounces (weight)		0
Tank													0	0	Product	Ounces (weight)		0
Tire													0	0	Product	Ounces (weight)		0
Treehole													1	0.25	Product	Ounces (weight)		4
Vault													0	0	Product	Ounces (weight)		0
Water meter box													0	0	Product	Ounces (weight)		0
Waterfall													0	0	Product	Ounces (weight)		0
Well													0	0	Product	Ounces (weight)		0
Total	Ounces (weight)		2	156	Product	Ounces (weight)		5	30	Product	Ounces (volume)		54	268.5	Product	Ounces (weight)		26

Table A43.

Application Sites:	Total Amount Used3144	Total Amount Type3245	Total Amount Unit3246	Teknar SC Comments	Altosid Briquets - # Treatments	Total Amount Used4663	Total Amount Type5764	Total Amount Unit5865	Atlosid Briquets Comments	Altosid Liquid Concentrate - # Treatments	Total Amount Used6966	Total Amount Type71067	Total Amount Unit71168	Altosid Liquid Concentrate Comments	Altosid Pellets - # Treatments	Total Amount Used111269
Bird Bath	0	Product	Ounces (volume)		25	28	Product	Other (specify in comments section)	briquet						2	0.5
Catch Basin	0	Product	Ounces (volume)		319	571	Product	Other (specify in comments section)	briquet						49	86
Creek	0	Product	Ounces (volume)		1	2	Product	Other (specify in comments section)	briquet						0	0
Culvert	0	Product	Ounces (volume)		4	9	Product	Other (specify in comments section)	briquet						4	1
Ditch	5.5	Product	Ounces (volume)		11	12	Product	Other (specify in comments section)	briquet						32	18.5
Drain Line	0	Product	Ounces (volume)		4	11	Product	Other (specify in comments section)	briquet						14	5.5
Drain Pipes	0	Product	Ounces (volume)		1	1	Product	Other (specify in comments section)	briquet						0	0
Fish Pond	0	Product	Ounces (volume)		1153	1695	Product	Other (specify in comments section)	briquet						32	8.75
Fountain	0	Product	Ounces (volume)		631	1006	Product	Other (specify in comments section)	briquet						36	11.5
Fresh H2O Marsh	0	Product	Ounces (volume)		0	0	Product	Other (specify in comments section)	briquet						0	0
Ground yellowjacket nest	0	Product	Ounces (volume)		0	0	Product	Other (specify in comments section)	briquet						0	0
H20 under Bldg	0	Product	Ounces (volume)		4	17	Product	Other (specify in comments section)	briquet						2	1.25
Horse Trough	0	Product	Ounces (volume)		11	25	Product	Other (specify in comments section)	briquet						0	0
Hot tub	0	Product	Ounces (volume)		53	54	Product	Other (specify in comments section)	briquet						2	0.5
Imp H2O	491.25	Product	Ounces (volume)		36	70	Product	Other (specify in comments section)	briquet	1	5	Product	Ounces (volume)		76	32.75
Misc container	0	Product	Ounces (volume)		179	354	Product	Other (specify in comments section)	briquet						39	12.25
Multiple	0	Product	Ounces (volume)		0	0	Product	Other (specify in comments section)	briquet						0	0
Paper Wasp Nest	0	Product	Ounces (volume)		0	0	Product	Other (specify in comments section)	briquet						0	0
Pond (natural)	8	Product	Ounces (volume)		3	6	Product	Other (specify in comments section)	briquet						1	2
Pothole	0	Product	Ounces (volume)		0	0	Product	Other (specify in comments section)	briquet						0	0
Reservoir	0	Product	Ounces (volume)		0	0	Product	Other (specify in comments section)	briquet						1	0.25
Salt Marsh	320	Product	Ounces (volume)		1	1	Product	Other (specify in comments section)	briquet						0	0
Seepage	0	Product	Ounces (volume)		0	0	Product	Other (specify in comments section)	briquet						1	0.25
Septic Seepage	0	Product	Ounces (volume)		0	0	Product	Other (specify in comments section)	briquet						0	0
Septic Tank	0	Product	Ounces (volume)		0	0	Product	Other (specify in comments section)	briquet						0	0
Sewage Treatment Plant	0	Product	Ounces (volume)		3	12	Product	Other (specify in comments section)	briquet						0	0
Spring	0	Product	Ounces (volume)		0	0	Product	Other (specify in comments section)	briquet						2	1.5
Storm Drain	0	Product	Ounces (volume)		2	2	Product	Other (specify in comments section)	briquet						0	0
Street Gutter	0	Product	Ounces (volume)		4	6	Product	Other (specify in comments section)	briquet						20	5.25
Sump	0	Product	Ounces (volume)		127	181	Product	Other (specify in comments section)	briquet						13	9.75
Swim Pool	0	Product	Ounces (volume)		70	255	Product	Other (specify in comments section)	briquet						3	1.5
Swim pool cover	0	Product	Ounces (volume)		4	11	Product	Other (specify in comments section)	briquet						4	1.75
Swim Pool Drain	0	Product	Ounces (volume)		4	4	Product	Other (specify in comments section)	briquet						0	0
Tank	0	Product	Ounces (volume)		17	41	Product	Other (specify in comments section)	briquet						1	10
Tire	0	Product	Ounces (volume)		3	4	Product	Other (specify in comments section)	briquet						9	2.5
Treehole	1	Product	Ounces (volume)		22	39	Product	Other (specify in comments section)	briquet						7	1.75
Vault	0	Product	Ounces (volume)		91	187	Product	Other (specify in comments section)	briquet						9	3
Water meter box	0	Product	Ounces (volume)		1	1	Product	Other (specify in comments section)	briquet						0	0
Waterfall	0	Product	Ounces (volume)		66	138	Product	Other (specify in comments section)	briquet						2	0.5
Well	0	Product	Ounces (volume)		18	24	Product	Other (specify in comments section)	briquet						0	0
Total	825.75	Product	Ounces (volume)		2868	4767	Product	Other (specify in comments section)		1	5	Product	Ounces (volume)		361	218.5

Table A43.

Application Sites:	Total Amount Type121370	Total Amount Unit121471	Altosid Pellets Comments	Altosid XR Briquets - # Treatments	Total Amount Used151875	Total Amount Type161976	Total Amount Unit162077	Altosid XR Briquets Comments	Altosid XR-G - # Treatments	Total Amount Used172178	Total Amount Type182279	Total Amount Unit182380	Altosid XR-G Comments	Altosid Liquid (Not-conentrate) # Treatments	Total Amount Used	Total Amount Type2	Total Amount Unit	Altosid Liquid (not-concentrate) Comments
Bird Bath	Product	Ounces (weight)		2	2	Product	Other (specify in comments section)	briquet	3	0.75	Product	Ounces (weight)						
Catch Basin	Product	Ounces (weight)		13	36	Product	Other (specify in comments section)	briquet	33	51.5	Product	Ounces (weight)						
Creek	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)						
Culvert	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	2	0.75	Product	Ounces (weight)						
Ditch	Product	Ounces (weight)		1	2	Product	Other (specify in comments section)	briquet	63	369.5	Product	Ounces (weight)		3	1.5	Product	Ounces (weight)	
Drain Line	Product	Ounces (weight)		2	3	Product	Other (specify in comments section)	briquet	5	1.25	Product	Ounces (weight)						
Drain Pipes	Product	Ounces (weight)		2	2	Product	Other (specify in comments section)	briquet	1	0.25	Product	Ounces (weight)						
Fish Pond	Product	Ounces (weight)		98	151	Product	Other (specify in comments section)	briquet	89	23.75	Product	Ounces (weight)						
Fountain	Product	Ounces (weight)		42	68	Product	Other (specify in comments section)	briquet	97	24.25	Product	Ounces (weight)						
Fresh H2O Marsh	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	4	190	Product	Ounces (weight)						
Ground yellowjacket nest	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)						
H20 under Bldg	Product	Ounces (weight)		1	1	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)						
Horse Trough	Product	Ounces (weight)		7	37	Product	Other (specify in comments section)	briquet	7	1.75	Product	Ounces (weight)						
Hot tub	Product	Ounces (weight)		7	7	Product	Other (specify in comments section)	briquet	1	0.25	Product	Ounces (weight)						
Imp H2O	Product	Ounces (weight)		4	13	Product	Other (specify in comments section)	briquet	109	665.5	Product	Ounces (weight)		15	46.25	Product	Ounces (weight)	
Misc container	Product	Ounces (weight)		11	22	Product	Other (specify in comments section)	briquet	160	46	Product	Ounces (weight)						
Multiple	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)						
Paper Wasp Nest	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)						
Pond (natural)	Product	Ounces (weight)		1	1	Product	Other (specify in comments section)	briquet	2	40.25	Product	Ounces (weight)		1	2	Product	Ounces (weight)	
Pothole	Product	Ounces (weight)		1	1	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)						
Reservoir	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	3	0.75	Product	Ounces (weight)		1	40	Product	Ounces (weight)	
Salt Marsh	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	5	720.75	Product	Ounces (weight)						
Seepage	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)						
Septic Seepage	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)						
Septic Tank	Product	Ounces (weight)		2	3	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)						
Sewage Treatment Plant	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	1	0.25	Product	Ounces (weight)						
Spring	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)						
Storm Drain	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)						
Street Gutter	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	35	8.75	Product	Ounces (weight)						
Sump	Product	Ounces (weight)		8	8	Product	Other (specify in comments section)	briquet	50	12.5	Product	Ounces (weight)						
Swim Pool	Product	Ounces (weight)		20	68	Product	Other (specify in comments section)	briquet	1	3	Product	Ounces (weight)						
Swim pool cover	Product	Ounces (weight)		1	1	Product	Other (specify in comments section)	briquet	1	1	Product	Ounces (weight)						
Swim Pool Drain	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)						
Tank	Product	Ounces (weight)		2	4	Product	Other (specify in comments section)	briquet	2	8	Product	Ounces (weight)						
Tire	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	18	4.5	Product	Ounces (weight)						
Treehole	Product	Ounces (weight)		1	1	Product	Other (specify in comments section)	briquet	2	0.5	Product	Ounces (weight)						
Vault	Product	Ounces (weight)		3	12	Product	Other (specify in comments section)	briquet	54	19.5	Product	Ounces (weight)						
Water meter box	Product	Ounces (weight)		0	0	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)						
Waterfall	Product	Ounces (weight)		7	12	Product	Other (specify in comments section)	briquet	30	7.5	Product	Ounces (weight)						
Well	Product	Ounces (weight)		3	3	Product	Other (specify in comments section)	briquet	0	0	Product	Ounces (weight)						
Total	Product	Ounces (weight)		239	458	Product	Other (specify in comments section)	briquet	778	2202.75	Product	Ounces (weight)		20	89.75	Product	Ounces (weight)	

Table A43.

Application Sites:	VectoLex WSP - # Treatments	Total Amount Used16	Total Amount Type17	Total Amount Unit18	VectoLex WSP Comments
Bird Bath					
Catch Basin					
Creek					
Culvert					
Ditch					
Drain Line					
Drain Pipes					
Fish Pond					
Fountain					
Fresh H2O Marsh					
Ground yellowjacket nest					
H20 under Bldg					
Horse Trough					
Hot tub					
Imp H2O					
Misc container					
Multiple					
Paper Wasp Nest					
Pond (natural)					
Pothole					
Reservoir					
Salt Marsh					
Seepage					
Septic Seepage					
Septic Tank					
Sewage Treatment Plant					
Spring					
Storm Drain					
Street Gutter					
Sump					
Swim Pool	1	6	Product	Ounces (weight)	
Swim pool cover					
Swim Pool Drain					
Tank					
Tire					
Treehole					
Vault					
Water meter box					
Waterfall					
Well					
Total	1	6	Product	Ounces (weight)	

Table A44. Pesticide Application Data for Spring 2012 – SMCMVCD

Application Sites:	VectoBac 12AS - # Treatments	Total Amount Used6	Total Amount Type7	Total Amount Unit7	VectoBac 12AS Comments	Altosid Pellets WSP - # Treatments	Total Amount Used11	Total Amount Type12	Total Amount Unit12	Altosid Pellets WSP Comments	BVA-2 - # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit18	BVA-2 Comments	VectoLex CG - # Treatments	Total Amount Used19	Total Amount Type20	Total Amount Unit20
Aerial yellowjacket nest																			
Bird Bath											4	1	Product	Ounces (volume)		2	0.5	Product	Ounces (weight)
Catch Basin						19	25	Product	Other (specify in comments section)	packet	296	64276.9	Product	Ounces (volume)		8	24.25	Product	Ounces (weight)
Creek											6	37.5	Product	Ounces (volume)		2	12.25	Product	Ounces (weight)
Culvert											4	1.75	Product	Ounces (volume)					
Ditch						3	12	Product	Other (specify in comments section)	packet	23	49.5	Product	Ounces (volume)		10	15	Product	Ounces (weight)
Drain Line											6	30.75	Product	Ounces (volume)		1	0.25	Product	Ounces (weight)
Drain Pipes											2	0.5	Product	Ounces (volume)					
Fish Pond	1	1	Product	Ounces (volume)		12	17	Product	Other (specify in comments section)	packet	345	177.5	Product	Ounces (volume)		38	10.25	Product	Ounces (weight)
Fountain						5	7	Product	Other (specify in comments section)	packet	141	45.25	Product	Ounces (volume)		24	6	Product	Ounces (weight)
Fresh H2O Marsh																			
Ground yellowjacket nest																			
H20 under Bldg											17	882.25	Product	Ounces (volume)					
Horse Trough											1	0.25	Product	Ounces (volume)		2	0.5	Product	Ounces (weight)
Hot tub						1	1	Product	Other (specify in comments section)	packet	19	8.25	Product	Ounces (volume)		2	0.5	Product	Ounces (weight)
Imp H2O	3	80	Product	Ounces (volume)		3	7	Product	Other (specify in comments section)	packet	40	131.25	Product	Ounces (volume)		4	6.5	Product	Ounces (weight)
Misc container						2	2	Product	Other (specify in comments section)	packet	42	238.75	Product	Ounces (volume)		6	1.5	Product	Ounces (weight)
Multiple																			
Pond (natural)											2	4.25	Product	Ounces (volume)					
Pothole											2	1.25	Product	Ounces (volume)					
Reservoir																			
Salt Marsh																			
Seepage											1	0.25	Product	Ounces (volume)					
Septic Seepage																			
Septic Tank											1	1	Product	Ounces (volume)					
Sewage Treatment Plant											16	7122	Product	Ounces (volume)					
Slough																			
Spring																			
Storm Drain																			
Street Gutter						1	1	Product	Other (specify in comments section)	packet	6	4.25	Product	Ounces (volume)					
Sump						4	4	Product	Other (specify in comments section)	packet	27	9.5	Product	Ounces (volume)					
Swim Pool											38	130	Product	Ounces (volume)		3	6.5	Product	Ounces (weight)
Swim pool cover											2	3.25	Product	Ounces (volume)					
Swim Pool Drain											1	0.25	Product	Ounces (volume)					
Tank											4	22.75	Product	Ounces (volume)					
Tire											1	0.25	Product	Ounces (volume)					
Treehole											3	0.75	Product	Ounces (volume)					
Vault											16	224.25	Product	Ounces (volume)		1	0.25	Product	Ounces (weight)
Water meter box																			
Waterfall											14	4.5	Product	Ounces (volume)		3	0.75	Product	Ounces (weight)
Well											5	2	Product	Ounces (volume)					
Paper wasp nest																			
Total	4	81	Product	Ounces (volume)		50	76	Product	Other (specify in comments section)	packet	1085	73411.9	Product	Ounces (volume)		106	85	Product	Ounces (weight)

Table A44.

Application Sites:	VectoLex CG Comments	Spheratax SPH (50G) WSP - # Treatments	Total Amount Used29	Total Amount Type30	Total Amount Unit30	Spheratax SPH (50G) WSP Comments	Delta Dust - # Treatments	Total Amount Used31	Total Amount Type32	Total Amount Unit32	Delta Dust Comments	VectoLex WDG - # Treatments	Total Amount Used3345	Total Amount Type3446	Total Amount Unit3447	VectoLex WDG Comments	Spectracide - # Treatments	Total Amount Used33452
Aerial yellowjacket nest																	5	30
Bird Bath																		
Catch Basin																		
Creek																		
Culvert																		
Ditch		1	1	Product	Other (specify in comments section)													
Drain Line												4	172	Product	Ounces (volume)			
Drain Pipes																		
Fish Pond		1	1	Product	Other (specify in comments section)													
Fountain																		
Fresh H2O Marsh																		
Ground yellowjacket nest							18	11.25	Product	Ounces (weight)							18	172.5
H20 under Bldg																		
Horse Trough																		
Hot tub																		
Imp H2O		1	8	Product	Other (specify in comments section)													
Misc container																		
Multiple																		
Pond (natural)																		
Pothole																		
Reservoir																		
Salt Marsh																		
Seepage																		
Septic Seepage																		
Septic Tank																		
Sewage Treatment Plant																		
Slough																		
Spring																		
Storm Drain																		
Street Gutter																		
Sump																		
Swim Pool																		
Swim pool cover																		
Swim Pool Drain																		
Tank																		
Tire																		
Treehole																		
Vault																		
Water meter box																		
Waterfall																		
Well																		
Paper wasp nest																	11	108.75
Total		3	10	Product	Other (specify in comments section)		18	11.25	Product	Ounces (weight)		4	172	Product	Ounces (volume)		34	311.25

Table A44.

Application Sites:	Total Amount Type34463	Total Amount Unit34474	Spectracide Comments	Natular G30 - # Treatments	Total Amount Used1317	Total Amount Type1418	Total Amount Unit1419	Natular G30 Comments	Spectracide Pro # Treatments	Total Amount Used1723	Total Amount Type1824	Total Amount Unit1825	Spectracide Pro Comments	Teknar SC - # Treatments	Total Amount Used3144	Total Amount Type3245	Total Amount Unit3246	Teknar SC Comments	Altosid Briquets - # Treatments
Aerial yellowjacket nest	Product	Ounces (volume)																	
Bird Bath																			18
Catch Basin				4	11.5	Product	Ounces (weight)												302
Creek				4	320	Product	Ounces (weight)												2
Culvert																			9
Ditch				2	4	Product	Ounces (weight)							4	48	Product	Ounces (volume)		18
Drain Line																			3
Drain Pipes																			2
Fish Pond																			633
Fountain				1	0.25	Product	Ounces (weight)												442
Fresh H2O Marsh				1	0.5	Product	Ounces (weight)							2	16	Product	Ounces (volume)		
Ground yellowjacket nest	Product	Ounces (volume)							10	303.75	Product	Ounces (volume)							
H20 under Bldg																			3
Horse Trough																			6
Hot tub																			25
Imp H2O				5	60.5	Product	Ounces (weight)							17	888	Product	Ounces (volume)		30
Misc container																			122
Multiple																			
Pond (natural)																			2
Pothole																			
Reservoir																			
Salt Marsh														1	480	Product	Ounces (volume)		
Seepage																			
Septic Seepage																			
Septic Tank																			1
Sewage Treatment Plant																			
Slough																			
Spring																			1
Storm Drain																			1
Street Gutter																			4
Sump																			75
Swim Pool																			38
Swim pool cover																			1
Swim Pool Drain																			1
Tank																			13
Tire																			2
Treehole														4	1	Product	Ounces (volume)		9
Vault																			52
Water meter box																			
Waterfall																			32
Well																			12
Paper wasp nest	Product	Ounces (volume)							3	105	Product	Ounces (volume)							
Total	Product	Ounces (volume)		17	396.75	Product	Ounces (weight)		13	408.75	Product	Ounces (volume)		28	1433	Product	Ounces (volume)		1859

Table A44.

Application Sites:	Total Amount Used4663	Total Amount Type5764	Total Amount Unit5865	Atlosid Briquets Comments	Altosid Liquid Concentrate - # Treatments	Total Amount Used6966	Total Amount Type71067	Total Amount Unit71168	Altosid Liquid Concentrate Comments	Altosid Pellets - # Treatments	Total Amount Used111269	Total Amount Type121370	Total Amount Unit121471	Altosid Pellets Comments	Altosid XR Briquets - # Treatments	Total Amount Used151875	Total Amount Type161976
Aerial yellowjacket nest																	
Bird Bath	18	Product	Other (specify in comments section)	briquet						1	0.25	Product	Ounces (weight)		2	2	Product
Catch Basin	779	Product	Other (specify in comments section)	briquet						73	268	Product	Ounces (weight)		77	136	Product
Creek	4	Product	Other (specify in comments section)	briquet						30	1351	Product	Ounces (weight)		4	5	Product
Culvert	12	Product	Other (specify in comments section)	briquet						5	2.25	Product	Ounces (weight)		1	1	Product
Ditch	29	Product	Other (specify in comments section)	briquet	1	1	Product	Ounces (volume)		56	282	Product	Ounces (weight)		8	13	Product
Drain Line	5	Product	Other (specify in comments section)	briquet						5	1.25	Product	Ounces (weight)				
Drain Pipes	2	Product	Other (specify in comments section)	briquet													
Fish Pond	951	Product	Other (specify in comments section)	briquet						52	24	Product	Ounces (weight)		176	250.5	Product
Fountain	703	Product	Other (specify in comments section)	briquet						37	9.25	Product	Ounces (weight)		69	93.5	Product
Fresh H2O Marsh																	
Ground yellowjacket nest																	
H20 under Bldg	12	Product	Other (specify in comments section)	briquet						1	8	Product	Ounces (weight)				
Horse Trough	7	Product	Other (specify in comments section)	briquet						1	0.5	Product	Ounces (weight)		3	6	Product
Hot tub	26	Product	Other (specify in comments section)	briquet						4	1	Product	Ounces (weight)		8	8	Product
Imp H2O	54	Product	Other (specify in comments section)	briquet	2	1.5	Product	Ounces (volume)		82	221.75	Product	Ounces (weight)		6	8	Product
Misc container	229	Product	Other (specify in comments section)	briquet						42	11.5	Product	Ounces (weight)		15	21	Product
Multiple																	
Pond (natural)	5	Product	Other (specify in comments section)	briquet											1	8	Product
Pothole															2	2	Product
Reservoir										1	0.25	Product	Ounces (weight)				
Salt Marsh																	
Seepage										1	0.25	Product	Ounces (weight)				
Septic Seepage																	
Septic Tank	4	Product	Other (specify in comments section)	briquet													
Sewage Treatment Plant																	
Slough																	
Spring	1	Product	Other (specify in comments section)	briquet											1	1	Product
Storm Drain	1	Product	Other (specify in comments section)	briquet											1	1	Product
Street Gutter	6	Product	Other (specify in comments section)	briquet						22	5.5	Product	Ounces (weight)		1	1	Product
Sump	107	Product	Other (specify in comments section)	briquet						24	6.25	Product	Ounces (weight)		24	27.5	Product
Swim Pool	163	Product	Other (specify in comments section)	briquet						4	1.75	Product	Ounces (weight)		16	40.5	Product
Swim pool cover	3	Product	Other (specify in comments section)	briquet						2	1.5	Product	Ounces (weight)				
Swim Pool Drain	1	Product	Other (specify in comments section)	briquet													
Tank	34	Product	Other (specify in comments section)	briquet						2	6	Product	Ounces (weight)		1	2	Product
Tire	3	Product	Other (specify in comments section)	briquet						3	0.75	Product	Ounces (weight)				
Treehole	9	Product	Other (specify in comments section)	briquet						3	0.75	Product	Ounces (weight)		1	1	Product
Vault	98	Product	Other (specify in comments section)	briquet						41	11.25	Product	Ounces (weight)		21	1094	Product
Water meter box																	
Waterfall	67	Product	Other (specify in comments section)	briquet						9	2.25	Product	Ounces (weight)		6	12	Product
Well	14	Product	Other (specify in comments section)	briquet						1	0.25	Product	Ounces (weight)		3	4	Product
Paper wasp nest																	
Total	3347	Product	Other (specify in comments section)	briquet	3	2.5	Product	Ounces (volume)		502	2217.5	Product	Ounces (weight)		447	1738	Product

Table A44.

Application Sites:	Total Amount Unit162077	Altosid XR Briquets Comments	Altosid XR-G - # Treatments	Total Amount Used172178	Total Amount Type182279	Total Amount Unit182380	Altosid XR-G Comments	Altosid Liquid (Not-conentrate) # Treatments	Total Amount Used	Total Amount Type2	Total Amount Unit	Altosid Liquid (not-concentrate) Comments	Pyrenone 25-5 # Treatments	Total Amount Used6	Total Amount Type7	Total Amount Unit8	Pyrenone 25-5 Comments
Aerial yellowjacket nest																	
Bird Bath	Other (specify in comments section)	briquet	17	5.5	Product	Ounces (weight)											
Catch Basin	Other (specify in comments section)	briquet	1	6	Product	Ounces (weight)											
Creek	Other (specify in comments section)	briquet															
Culvert	Other (specify in comments section)	briquet	1	0.25	Product	Ounces (weight)											
Ditch	Other (specify in comments section)	briquet	65	266.75	Product	Ounces (weight)		3	5	Product	Ounces (volume)						
Drain Line			2	0.5	Product	Ounces (weight)											
Drain Pipes																	
Fish Pond	Other (specify in comments section)	briquet	13	3.25	Product	Ounces (weight)											
Fountain	Other (specify in comments section)	briquet	20	5	Product	Ounces (weight)											
Fresh H2O Marsh			2	322.5	Product	Ounces (weight)		2	3	Product	Ounces (volume)						
Ground yellowjacket nest																	
H20 under Bldg													1	4.5	Product	Ounces (volume)	
Horse Trough	Other (specify in comments section)	briquet	8	2	Product	Ounces (weight)											
Hot tub	Other (specify in comments section)	briquet	1	0.25	Product	Ounces (weight)											
Imp H2O	Other (specify in comments section)	briquet	81	1808.5	Product	Ounces (weight)		18	130.5	Product	Ounces (volume)						
Misc container	Other (specify in comments section)	briquet	43	12.25	Product	Ounces (weight)											
Multiple																	
Pond (natural)	Other (specify in comments section)	briquet	2	44	Product	Ounces (weight)											
Pothole	Other (specify in comments section)	briquet															
Reservoir			3	40.25	Product	Ounces (weight)											
Salt Marsh			19	2586	Product	Ounces (weight)		1	60	Product	Ounces (volume)						
Seepage			2	0.5	Product	Ounces (weight)											
Septic Seepage																	
Septic Tank																	
Sewage Treatment Plant																	
Slough																	
Spring	Other (specify in comments section)	briquet															
Storm Drain	Other (specify in comments section)	briquet															
Street Gutter	Other (specify in comments section)	briquet	8	2	Product	Ounces (weight)											
Sump	Other (specify in comments section)	briquet	15	3.75	Product	Ounces (weight)											
Swim Pool	Other (specify in comments section)	briquet	1	0.25	Product	Ounces (weight)											
Swim pool cover			1	0.25	Product	Ounces (weight)											
Swim Pool Drain																	
Tank	Other (specify in comments section)	briquet	2	3	Product	Ounces (weight)											
Tire			9	7	Product	Ounces (weight)											
Treehole	Other (specify in comments section)	briquet															
Vault	Other (specify in comments section)	briquet	18	12	Product	Ounces (weight)											
Water meter box																	
Waterfall	Other (specify in comments section)	briquet	3	0.75	Product	Ounces (weight)											
Well	Other (specify in comments section)	briquet															
Paper wasp nest																	
Total	Other (specify in comments section)	briquet	337	5132.5	Product	Ounces (weight)		24	198.5	Product	Ounces (volume)		1	4.5	Product	Ounces (volume)	

Table A45. Pesticide Product Key – SMCMVCD

Product	Active Ingredient	Vector
Altosid Briquets	Methoprene	Mosquito
Altosid Liquid Larvicide	Methoprene	Mosquito
Altosid Liquid Larvicide Concentrate	Methoprene	Mosquito
Altosid Pellets	Methoprene	Mosquito
Altosid Pellets WSP	Methoprene	Mosquito
Altosid XR-Briquets	Methoprene	Mosquito
Altosid XR-G (granules)	Methoprene	Mosquito
Astro®, Ortho® products, Bonide® products, Tengard® products, etc.	Permethrin	Yellow Jacket / Wasp
Bayer Pyrenone 25-5	Pyrethrins and Piperonyl Butoxide	Mosquito
BVA 2	Petroleum Distillate	Mosquito
Delta Dust	Deltamethrin	Yellow Jacket / Wasp
Drione	Pyrethrin and Piperonyl Butroxide and Amorphous Silica Gel	Yellow Jacket / Wasp
Mosquito Larvicide GB-1111	Aliphatic Petroleum Hydrocarbons	Mosquito
Natular G30	Spinosad	Mosquito
Spectracide Pro®	Tetramethrin and Permethrin and Piperonyl Butoxide	Yellow Jacket / Wasp
Spectracide®	Prallethrin and Lambda-cyhalothrin	Yellow Jacket / Wasp
Teknar SC	Bacillus Thuringiensis Israelensis	Mosquito
VectoBac 12AS	Bacillus Thuringiensis Israelensis	Mosquito
VectoLex CG Biologic	Bacillus Sphaericus	Mosquito
VectoLex WDG	Bacillus Sphaericus	Mosquito
VectoLex WSP	Bacillus Sphaericus	Mosquito
Wasp-Freeze	Phenothrin and Trans Allethrin	Yellow Jacket / Wasp

Table A46. **Herbicide Application Data for Summer 2011 – NCMAD**

Application Sites	Aquamaster # Treatmens	Total Amount Used	Total Amount Type	Total Amount Unit	Aquamaster Comments	Blazon Pattern Indicator # Treatments	Total Amount Used2	Total Amount Type3	Total Amount Unit4	Blazon Pattern Indicator Comments	BullsEye Pattern Idicator # Treatments	Total Amount Used5
Access Roads	15	883.5	Product	Ounces (volume)		6	160	Product	Ounces (volume)		14	103.7
Pond Levees												
Top and Exterior Slopes of Waste Water Ponds	17	1783.5	Product	Ounces (volume)		3	64	Product	Ounces (volume)		17	222.3
Interior Margins/Slopes of Waste Water Ponds	14	975.6	Product	Ounces (volume)		3	80	Product	Ounces (volume)		13	107.2
Napa River Islands/Embankments												
Waste Water Spray Fields	2	64	Product	Ounces (volume)		3	96	Product	Ounces (volume)		5	28.4
Ditches/Channels	2	384	Product	Ounces (volume)							1	16
Empty Lots/Fields	4	93.4	Product	Ounces (volume)							3	127.2
Total	54	4184	Product	Ounces (volume)		15	400	Product	Ounces (volume)		53	604.8

Table A46.

Application Sites	Total Amount Type6	Total Amount Unit7	BullsEye Pattern Idicator Comments	No Foam A # Treatments	Total Amount Used20	Total Amount Type21	Total Amount Unit22	No Foam A Comments	Pro-Spreader Activator # Treatments	Total Amount Used29	Total Amount Type30	Total Amount Unit31
Access Roads	Product	Ounces (volume)		1	1.5	Product	Ounces (volume)		3	18.6	Product	Ounces (volume)
Pond Levees												
Top and Exterior Slopes of Waste Water Ponds	Product	Ounces (volume)		1	15	Product	Ounces (volume)		5	33.8	Product	Ounces (volume)
Interior Margins/Slopes of Waste Water Ponds	Product	Ounces (volume)		1	13.5	Product	Ounces (volume)		5	24.6	Product	Ounces (volume)
Napa River Islands/Embankments												
Waste Water Spray Fields	Product	Ounces (volume)										
Ditches/Channels	Product	Ounces (volume)										
Empty Lots/Fields	Product	Ounces (volume)										
Total	Product	Ounces (volume)		3	30	Product	Ounces (volume)		13	77	Product	Ounces (volume)

Table A46.

Application Sites	Pro-Spreader Activator Comments	R-11 Spreader Activator # Treatments	Total Amount Used32	Total Amount Type33	Total Amount Unit34	R-11 Spreader Activator Comments	Roundup Pro # Treaments	Total Amount Used35	Total Amount Type36	Total Amount Unit37	Roundup Pro Comments	Roundup Pro Max # Treatments
Access Roads		13	529.85	Product	Ounces (volume)		2	51.2	Product	Ounces (volume)		1
Pond Levees												
Top and Exterior Slopes of Waste Water Ponds		10	667.95	Product	Ounces (volume)		2	301.4	Product	Ounces (volume)		
Interior Margins/Slopes of Waste Water Ponds		8	350.1	Product	Ounces (volume)		2	70.4	Product	Ounces (volume)		
Napa River Islands/Embankments												
Waste Water Spray Fields		4	273.7	Product	Ounces (volume)							
Ditches/Channels		2	96	Product	Ounces (volume)							
Empty Lots/Fields		4	49.1	Product	Ounces (volume)		2	189	Product	Ounces (volume)		1
Total		41	1966.7	Product	Ounces (volume)		8	612	Product	Ounces (volume)		2

Table A46.

Application Sites	Total Amount Used38	Total Amount Type39	Total Amount Unit40	Roundup Pro Max Comments	Buccaneer # Treatments	Total Amount Used47	Total Amount Type48	Total Amount Unit49	Buccaneer Comments
Access Roads	102.4	Product	Ounces (volume)		3	588.8	Product	Ounces (volume)	
Pond Levees									
Top and Exterior Slopes of Waste Water Ponds					1	204.8	Product	Ounces (volume)	
Interior Margins/Slopes of Waste Water Ponds					1	256	Product	Ounces (volume)	
Napa River Islands/Embankments									
Waste Water Spray Fields					2	358.4	Product	Ounces (volume)	
Ditches/Channels									
Empty Lots/Fields	921.6	Product	Ounces (volume)						
Total	1024	Product	Ounces (volume)		7	1408	Product	Ounces (volume)	

Table A47. **Herbicide Application Data for Fall 2011 – NCMAD**

Application Sites	Aquamaster # Treatmens	Total Amount Used	Total Amount Type	Total Amount Unit	Aquamaster Comments	Blazon Pattern Indicator # Treatments	Total Amount Used2	Total Amount Type3	Total Amount Unit4	Blazon Pattern Indicator Comments	BullsEye Pattern Idicator # Treatments	Total Amount Used5
Access Roads	26	3437.4	Product	Ounces (volume)		14	1169	Product	Ounces (volume)		49	933.7
Pond Levees												
Top and Exterior Slopes of Waste Water Ponds	24	7456.3	Product	Ounces (volume)		7	1408.6	Product	Ounces (volume)		65	2612.1
Interior Margins/Slopes of Waste Water Ponds	21	4150.4	Product	Ounces (volume)		7	1544	Product	Ounces (volume)		61	1502.8
Napa River Islands/Embankments	11	11240	Product	Ounces (volume)							9	282
Waste Water Spray Fields	1	51.2	Product	Ounces (volume)		4	467.2	Product	Ounces (volume)		5	81
Ditches/Channels	3	768	Product	Ounces (volume)								
Empty Lots/Fields	1	42.3	Product	Ounces (volume)							4	120
Total	87	27145.6	Product	Ounces (volume)		32	4588.8	Product	Ounces (volume)		193	5531.6

Table A47.

Application Sites	Total Amount Type6	Total Amount Unit7	BullsEye Pattern Idicator Comments	Competitor # Treatments	Total Amount Used8	Total Amount Type9	Total Amount Unit10	Competitor Comments	Karmex XP # Treatments	Total Amount Used14	Total Amount Type15	Total Amount Unit16
Access Roads	Product	Ounces (volume)							45	7907.2	Product	Ounces (weight)
Pond Levees												
Top and Exterior Slopes of Waste Water Ponds	Product	Ounces (volume)							57	26949.6	Product	Ounces (weight)
Interior Margins/Slopes of Waste Water Ponds	Product	Ounces (volume)							53	18132	Product	Ounces (weight)
Napa River Islands/Embankments	Product	Ounces (volume)		12	1264	Product	Ounces (volume)					
Waste Water Spray Fields	Product	Ounces (volume)							1	32	Product	Ounces (weight)
Ditches/Channels									3	1120	Product	Ounces (weight)
Empty Lots/Fields	Product	Ounces (volume)							3	195.2	Product	Ounces (weight)
Total	Product	Ounces (volume)		12	1264	Product	Ounces (volume)		162	54336	Product	Ounces (weight)

Table A47.

Application Sites	Karmex XP Comments	Oust XP # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit19	Oust XP Comments	No Foam A # Treatments	Total Amount Used20	Total Amount Type21	Total Amount Unit22	No Foam A Comments	Polaris # Treatments	Total Amount Used26
Access Roads		63	383.69	Product	Ounces (weight)		10	45.6	Product	Ounces (volume)			
Pond Levees													
Top and Exterior Slopes of Waste Water Ponds		74	865.09	Product	Ounces (weight)		11	605.6	Product	Ounces (volume)			
Interior Margins/Slopes of Waste Water Ponds		67	580	Product	Ounces (weight)		10	276.8	Product	Ounces (volume)			
Napa River Islands/Embankments		7	68	Product	Ounces (weight)							11	9216
Waste Water Spray Fields		1	4.8	Product	Ounces (weight)								
Ditches/Channels		1	8	Product	Ounces (weight)								
Empty Lots/Fields		3	5.88	Product	Ounces (weight)								
Total		216	1915.46	Product	Ounces (weight)		31	928	Product	Ounces (volume)		11	9216

Table A47.

Application Sites	Total Amount Type27	Total Amount Unit28	Polaris Comments	Pro-Spreader Activator # Treatments	Total Amount Used29	Total Amount Type30	Total Amount Unit31	Pro-Spreader Activator Comments	R-11 Spreader Activator # Treatments	Total Amount Used32	Total Amount Type33	Total Amount Unit34
Access Roads				32	2585.2	Product	Ounces (volume)		24	1086.8	Product	Ounces (volume)
Pond Levees												
Top and Exterior Slopes of Waste Water Ponds				31	2840.89	Product	Ounces (volume)		34	3177.7	Product	Ounces (volume)
Interior Margins/Slopes of Waste Water Ponds				28	3042.9	Product	Ounces (volume)		29	1690.6	Product	Ounces (volume)
Napa River Islands/Embankments	Product	Ounces (volume)		11	311	Product	Ounces (volume)					
Waste Water Spray Fields				8	889.6	Product	Ounces (volume)					
Ditches/Channels									3	224	Product	Ounces (volume)
Empty Lots/Fields									4	40.8	Product	Ounces (volume)
Total	Product	Ounces (volume)		110	9669.59	Product	Ounces (volume)		94	6219.9	Product	Ounces (volume)

Table A47.

Application Sites	R-11 Spreader Activator Comments	Diuron 80 # Treatments	Toal Amount Used	Total Amount Type2	Total Amount Unit2	Diuron 80 Comments
Access Roads		18	8343	Product	Ounces (weight)	
Pond Levees						
Top and Exterior Slopes of Waste Water Ponds		17	6372.8	Product	Ounces (weight)	
Interior Margins/Slopes of Waste Water Ponds		15	5318.6	Product	Ounces (weight)	
Napa River Islands/Embankments						
Waste Water Spray Fields		8	3289.6	Product	Ounces (weight)	
Ditches/Channels						
Empty Lots/Fields						
Total		58	23324	Product	Ounces (weight)	

Table A48. **Herbicide Application Data for Winter 2012 – NCMAD**

Application Sites	Aquamaster # Treatmens	Total Amount Used	Total Amount Type	Total Amount Unit	Aquamaster Comments	BullsEye Pattern Idicator # Treatments	Total Amount Used5	Total Amount Type6	Total Amount Unit7	BullsEye Pattern Idicator Comments	Karmex XP # Treatments	Total Amount Used14
Access Roads	4	375.9	Product	Ounces (volume)		5	70	Product	Ounces (volume)		5	700.8
Pond Levees												
Top and Exterior Slopes of Waste Water Ponds	4	824.2	Product	Ounces (volume)		5	157.4	Product	Ounces (volume)		5	1574.4
Interior Margins/Slopes of Waste Water Ponds	3	342	Product	Ounces (volume)		3	72.8	Product	Ounces (volume)		4	742.4
Napa River Islands/Embankments											2	864
Waste Water Spray Fields	2	403.2	Product	Ounces (volume)		2	86.4	Product	Ounces (volume)			
Ditches/Channels												
Empty Lots/Fields	1	30.7	Product	Ounces (volume)		2	5.4	Product	Ounces (volume)		1	38.4
Total	14	1976	Product	Ounces (volume)		17	392	Product	Ounces (volume)		17	3920

Table A48.

Application Sites	Total Amount Type15	Total Amount Unit16	Karmex XP Comments	Oust XP # Treatments	Total Amount Used17	Total Amount Type18	Total Amount Unit19	Oust XP Comments	No Foam A # Treatments	Total Amount Used20	Total Amount Type21	Total Amount Unit22	No Foam A Comments
Access Roads	Product	Ounces (weight)		5	17.52	Product	Ounces (weight)		1	4.8	Product	Ounces (volume)	
Pond Levees													
Top and Exterior Slopes of Waste Water Ponds	Product	Ounces (weight)		5	39.36	Product	Ounces (weight)		1	4.8	Product	Ounces (volume)	
Interior Margins/Slopes of Waste Water Ponds	Product	Ounces (weight)		3	18.2	Product	Ounces (weight)		1	6.4	Product	Ounces (volume)	
Napa River Islands/Embankments	Product	Ounces (weight)											
Waste Water Spray Fields				2	21.6	Product	Ounces (weight)						
Ditches/Channels													
Empty Lots/Fields	Product	Ounces (weight)											
Total	Product	Ounces (weight)		15	96.68	Product	Ounces (weight)		3	16	Product	Ounces (volume)	

Table A48.

Application Sites	R-11 Spreader Activator # Treatments	Total Amount Used32	Total Amount Type33	Total Amount Unit34	R-11 Spreader Activator Comments
Access Roads	4	138.6	Product	Ounces (volume)	
Pond Levees					
Top and Exterior Slopes of Waste Water Ponds	4	134.8	Product	Ounces (volume)	
Interior Margins/Slopes of Waste Water Ponds	2	144	Product	Ounces (volume)	
Napa River Islands/Embankments					
Waste Water Spray Fields	2	172.8	Product	Ounces (volume)	
Ditches/Channels					
Empty Lots/Fields	2	10.6	Product	Ounces (volume)	
Total	14	600.8	Product	Ounces (volume)	

Table A49. **Herbicide Application Data for Spring 2012 – NCMAD**

Application Sites	Aquamaster # Treatmens	Total Amount Used	Total Amount Type	Total Amount Unit	Aquamaster Comments	Blazon Pattern Indicator # Treatments	Total Amount Used2	Total Amount Type3	Total Amount Unit4	Blazon Pattern Indicator Comments	BullsEye Pattern Idicator # Treatments	Total Amount Used5
Access Roads	13	646.9	Product	Ounces (volume)		4	89.6	Product	Ounces (volume)		13	94.4
Pond Levees												
Top and Exterior Slopes of Waste Water Ponds	15	1931.8	Product	Ounces (volume)		3	102.4	Product	Ounces (volume)		15	252
Interior Margins/Slopes of Waste Water Ponds	14	1104.3	Product	Ounces (volume)		3	128	Product	Ounces (volume)		14	149.6
Napa River Islands/Embankments												
Waste Water Spray Fields												
Ditches/Channels												
Empty Lots/Fields	1	256	Product	Ounces (volume)							2	32
Total	43	3939	Product	Ounces (volume)		10	320	Product	Ounces (volume)		44	528

Table A49.

Application Sites	Total Amount Type6	Total Amount Unit7	BullsEye Pattern Idicator Comments	Competitor # Treatments	Total Amount Used8	Total Amount Type9	Total Amount Unit10	Competitor Comments	No Foam A # Treatments	Total Amount Used20	Total Amount Type21	Total Amount Unit22
Access Roads	Product	Ounces (volume)							10	35.1	Product	Ounces (volume)
Pond Levees												
Top and Exterior Slopes of Waste Water Ponds	Product	Ounces (volume)							12	173.2	Product	Ounces (volume)
Interior Margins/Slopes of Waste Water Ponds	Product	Ounces (volume)							11	173.7	Product	Ounces (volume)
Napa River Islands/Embankments				9	288	Product	Ounces (volume)					
Waste Water Spray Fields												
Ditches/Channels												
Empty Lots/Fields	Product	Ounces (volume)										
Total	Product	Ounces (volume)		9	288	Product	Ounces (volume)		33	382	Product	Ounces (volume)

Table A49.

Application Sites	No Foam A Comments	Polaris # Treatments	Total Amount Used26	Total Amount Type27	Total Amount Unit28	Polaris Comments	Pro-Spreader Activator # Treatments	Total Amount Used29	Total Amount Type30	Total Amount Unit31	Pro-Spreader Activator Comments	R-11 Spreader Activator # Treatments
Access Roads							1	6.4	Product	Ounces (volume)		3
Pond Levees												
Top and Exterior Slopes of Waste Water Ponds		1	72	Product	Ounces (volume)		1	25.6	Product	Ounces (volume)		2
Interior Margins/Slopes of Waste Water Ponds							1	32	Product	Ounces (volume)		2
Napa River Islands/Embankments		4	432	Product	Ounces (volume)							
Waste Water Spray Fields												
Ditches/Channels												
Empty Lots/Fields												1
Total		5	504	Product	Ounces (volume)		3	64	Product	Ounces (volume)		8

Table A49.

Application Sites	Total Amount Used32	Total Amount Type33	Total Amount Unit34	R-11 Spreader Activator Comments	Roundup Pro # Treaments	Total Amount Used35	Total Amount Type36	Total Amount Unit37	Roundup Pro Comments
Access Roads	204.8	Product	Ounces (volume)		2	460.8	Product	Ounces (volume)	
Pond Levees									
Top and Exterior Slopes of Waste Water Ponds	332.8	Product	Ounces (volume)		2	537.6	Product	Ounces (volume)	
Interior Margins/Slopes of Waste Water Ponds	102.4	Product	Ounces (volume)		2	537.6	Product	Ounces (volume)	
Napa River Islands/Embankments									
Waste Water Spray Fields									
Ditches/Channels									
Empty Lots/Fields	128	Product	Ounces (volume)						
Total	768	Product	Ounces (volume)		6	1536	Product	Ounces (volume)	

Table A50. Herbicide Product Key – NCMAD

Product	Active Ingredient	Vector
Aquamaster	Glyphosate	Weed
Blazon Pattern Indicator	Polymetric Colorant (proprietary)	Weed
BullsEye Pattern Indicator	Proprietary Colorant	Weed
Competitor	Modified Vegetable Oil	Weed
Karmex XP	Diuron	Weed
Oust XP	Sulfometuron Methyl	Weed
No Foam A	Alkyl Phenol Ethoxylate / Isopropanol	Weed
Polaris	Imazapyr	Weed
Pro-Spreader Activator	Alkyl Phenol Ethoxylate / Isopropanol	Weed
R-11 Spreader Activator		Weed
Roundup Pro	Glyphosate	Weed
Buccaneer	Glyphosate	Weed

Ecological & Human Health
Assessment Report

ATTACHMENT

B

REVIEW OF ADDITIONAL LITERATURE FOR METHOPRENE, BTI AND BACILLUS SPHAERICUS

B.1 Introduction

This attachment serves as an update and supplement to the information about chemical toxicity provided in Appendix B, Ecological & Human Health Assessment Report (June 2013). In that document, approximately 46 active ingredients and numerous products were reviewed, including dozens of papers and documents that provide supporting information about the toxicity for each chemical. While the information provided in the original report was developed using the information available at the time, this attachment is a follow-up review of additional information not included previously in Appendix B for three of the 46 chemicals: 1) methoprene; 2) Bti (*Bacillus thuringiensis israelensis*) and 3) *B. sphaericus* (*Bacillus sphaericus*).

Fifty-one additional publications and reports about these three pesticides were identified and evaluated for consistency with the original assessment conclusions in Appendix B and subsequently in the Districts' Draft PEIRs. This attachment addresses several publications that will be included to supplement Appendix B. Most of these additional articles report using pesticide exposures that are generally longer, or at higher concentrations, than those used by the Districts. Several other factors are presented that may confound their reported results. Based on the information in these reviews, and comparisons of their reported exposure rates, the finding is that in general, the exposures are not relevant to District application scenarios. None of the additional reports contain information that would substantially change the impact assessments in the Draft PEIRs, i.e., would not change a conclusion of no impact or less-than-significant impact to potentially significant impact.

B.2 Approach to the Current Reviews

The objective of Appendix B was to review all active ingredients in use (or proposed for future use) and then to identify those active ingredients that may pose potential human health or ecological health concerns when used by the Districts. Extensive literature reviews were conducted to document the relevant reported toxicity and environmental fate of the pesticides of interest to the Districts. Following the examination in 2012 and 2013 of the reports on the Districts' pesticides, it was determined that three pesticides are of special interest as key methods of mosquito control and additional literature should be reviewed. The reports cited in this attachment are, therefore, focused on the three pesticides: 1) methoprene; 2) Bti; and 3) *B. sphaericus*. These pesticides are detailed and summarized in Chapter 4 of Appendix B (especially Table 4-1). Documented effects of each of these pesticides are presented in Tables 3-1, 3-2, and 3-3 of Chapter 3 of Appendix B. The reports evaluated for this attachment are supplemental to the original reports and generally include and publications not previously evaluated in Appendix B.

B.3 Conclusions

The additional reports listed in this attachment suggest that no modifications to the hazard assessments and conclusions provided in each District's Draft PEIR or Appendix B should be necessary for methoprene, Bti, or *B*. *sphaericus.*

Additional Methoprene Publications Reviewed

Publication Authors	Summary of Reported Findings
Ali, A., R.J. Lobinske, R.J. Leckel, N. Carandang and A. Mazumdar. 2008. Population Survey and Control of Chironomidae (Diptera) in Wetlands in Northeastern Florida, USA. Florida Entomologist 91(3):446-452.	Two species of Chironomids, *Glyptotendipes paripes* and *Goeldichironomus carus* in Florida wetlands were evaluated for sensitivity to Temephos, Bti, and s-methoprene. This paper reviews the comparison of these larvicides both for efficacy and in cost. The summary of the paper suggests that Bti and S methoprene be used in rotation with Tim FR's for Midge control. The authors suggest that this approach in an IPM technique would have only temporary and reversible impact on nontarget biota. However, the study did not actually evaluate nontargets in the field as part of the study. Note: label rate is 5 to 10 lbs/acre for midges in wastewater ponds and systems. This study used methoprene pellets at a rate of 7.7 to 15 lbs/ acre to achieve 80 and 90% reduction of adult emergence in experimental field plots. Lab bioassys used rates that exceeded 18 or more times what would occur with exposure to maximum label rates.
Anonymous. 2007. Canadian Water Quality Guidelines for the Protection of Aquatic Life. Methoprene. Canadian Council of Ministers of the Environment. 11pp	Listing of Methoprene freshwater target levels for acceptable risk…..0.09 µg/L target organism, and 0.53 µg/L management value considered as target thresholds. These are values of water concentrations safe to non-target species.
Brown, M., D. Thomas, P. Mason, J.G. Greenwood and B.H. Kay. 1998. Laboratory and Field Evaluation of the Efficacy of Four Insecticides for *Aedes vigilax* (Diptera: Culicidae) and Toxicity to the Nontarget Shrimp *Leander tenuicornis* (Decapoda: Palaemonidae). J. Econ. Ent. 92(5):1045-1051.	This report describes laboratory and field tests of the toxicity of two organophosphate compounds (temephos and pirimiphosmethyl) and s-methoprene and *Bacillus thuringiensis ssp. israelensis* (Bti) to a saltwater mosquito (*Aedes vigilax*) including an evaluation of the selectivity for the mosquito and possible toxicity to a non-target shrimp *Leander tenuicornis* (a Decapod). In addition to developing LC 50 values the report includes measures of selectivity of each pesticide for the target organisms versus nontarget. The methoprene applications were highly toxic to the saltwater mosquito while not affecting survival of the shrimp that inhabit the same saltwater marsh areas. In addition, s-methoprene did not affect water quality. The authors suggest that methoprene is an "ideal pesticide for continued control of *Ae. vigilax* in Australian saltwater ponds.
Butler, M., H.S. Ginsburg, R.A. LeBrun and A. Gettman. 2010. Evaluation of Nontarget Effects of Methoprene Applied to Catch Basins for Mosquito Control. J. Vector Ecology. 35(2):372-384.	Measurements of methoprene concentrations were made from water in catch basins that were treated with methoprene and from an adjoining salt pond near where the catch basins emptied. Concentrations of methoprene in catch basins and at drainage outlets, after application at mosquito control label rates, were 0.5 ppb and lower, which was below levels determined to be detrimental to organisms other than mosquitoes. Effects of methoprene on communities of organisms that live in catch basins (lab simulated as well as field) were also evaluated. No evidence of declines in abundance of any taxa or consistent change in community level parameters (e.g. species richness, dominance-diversity relationships) was found.
Craggs, R., L. Golding, S. Clearwater, L. Susaria and W. Donovan. 2005. Control of Chironomid Midge Larvae in Wastewater Stabilization Ponds: Comparison of Five Compounds. Water Sci. Tech. 51(12):191-199.	The efficacy of Maldison, an organophosphate insecticide, was compared to *Bacillus thuringiensis* var*. israelensis* (Bti), methoprene, pyriproxyfen, and diflubenzuron. During 21-day small-scale trials, Bti, diflubenzuron and Maldison reduced live larval numbers by 80-89% compared to controls and adult emergence was markedly reduced by all compounds (72-96%). Large-scale trials with methoprene (Prolink XRG granules) at 32 kg total ingredient/ha (to give a final field concentration in the water column of 50 µg/L) reduced midge emergence by approximately 80% over 25 days. It should be noted that the rate of methoprene used in the large-scale field trials was significantly higher than maximum labels rates allowed for mosquito control applications.

Additional Methoprene Publications Reviewed

Publication Authors	Summary of Reported Findings
Csondes, A. 2004. Environmental Fate of Methoprene. 6 pp whitepaper prepared by Cal. DPR.	Review of methoprene characteristics, physiochemical etc., includes tables of reported and verified toxicity and fate and transport properties. Methoprene is an insect growth regulator, used to control a variety of insect species, and is considered a biochemical pesticide. Rather than direct toxicity, methoprene disrupts the insects' metamorphosis and life cycle, thus hindering their ability to reach adulthood and successful reproduction. This paper provides an overview of the uses of Methoprene and descriptions of some special formulations used for mosquito control, especially in floodwater sites, rice cultivations, storm drains, ponds and water treatment works
Davis, R.S. and R. Peterson. 2008. Effects of Single and Multiple Applications of Mosquito Insecticides on Nontarget Arthropods. J. Amer. Mosq. Cont. Assoc. 24(2):270-280.	Experiments were conducted to assess the acute impacts of mosquito adulticides (permethrin and d-phenothrin) and larvicides (*Bacillus thuringiensis israelensis* and methoprene) on nontarget aquatic and terrestrial arthropods after a single application. This experiment was conducted in 2004 and 2005 with methoprene on nontarget terrestrial arthropods using a single application. For aquatic non-target species, no adverse treatment effects were observed. In general, nearly all of the responses evaluated for either study indicated few, if any, clear adverse effects from methoprene applications. Methoprene was used at near maximum label rate (93% of maximum which was 0.20 oz. AI per acre)
Degitz, S., E.J. Durhan, J.E. Tietge, P.A. Koslan, G.W. Holcombe and G.T. Ankley. 2003. Developmental Toxicity of Methoprene and Several Degradation Products in *Xenopus laevis*. Aquatic Toxicol. 64:97-105.	Methoprene is an insect juvenile growth hormone mimic, which inhibits pupation and is used for the control of emergent insect pests such as mosquitoes. Researchers have hypothesized that methoprene use in US may be a contributing factor to the recent increase in malformed amphibians. However, little is known concerning the developmental toxicity of methoprene and its degradation products in amphibians. In these studies, the aqueous stability and developmental toxicity of methoprene and several degradation products (methoprene acid, methoprene epoxide, 7-methoxycitronellal, and 7-methoxycitronellic acid) were examined. *Xenopus laevis* embryos (stage 8) were exposed to the test chemicals (aquatic test chambers with total immersion) for 96 h. Assays were conducted under static renewal (24 h) conditions and chemical concentrations in water were measured at the beginning and end of the renewal periods. Methoprene exposure did not result in developmental toxicity at concentrations up to 2 mg/l (equivalent to 2000 ppb which is 400 times max label application rate for mosquito control), which is slightly higher than its water solubility. Methoprene acid, a relatively minor degradation product, produced developmental toxicity when concentrations exceeded 1.25 mg/l. Methoprene epoxide and 7-methoxycitronellal caused developmental toxicity at concentrations of 2.5 mg/l and higher. 7-Methoxycitronellic acid was not developmentally toxic at a test concentration as high as 30 mg/l. These data indicate that methoprene and its degradation products are not potent development toxicants in *X. laevis*. This, in combination with the fact that field applications of sustained-release formulations of methoprene result in methoprene concentrations that do not typically exceed 0.01 mg/l, suggests that concerns for methoprene-mediated developmental toxicity to amphibians may be unwarranted.

Additional Methoprene Publications Reviewed

Publication Authors	Summary of Reported Findings
Stark, J.D. 2005. A Review and Update of the Report "Environmental and Health Impacts of the Insect Juvenile Hormone Analogue, S-Methoprene" 1999. Report for the New Zealand Ministry of Health. 32pp.	Conclusions of this report were: 1) although methoprene is toxic to 12 orders of insects and may have effects on other nontarget organisms, particularly other nontarget arthropods, methoprene is one of the least environmentally damaging mosquito control agents and poses little risk to human and animal health; 2) concentrations of methoprene necessary to control mosquitoes (1 ppb) are much lower than the concentrations necessary to cause damage to populations of most nontarget organisms. Short half-life in the environment unlikely to accumulate in various environmental compartments. Although new literature has been published showing declines in insect biomass due to long-term use of methoprene and Bti in freshwater wetlands in Minnesota, USA, no evidence for permanent damage to ecosystem function has been found. The causal agent(s) of frog deformities in the USA has still not been clearly elucidated. Some believe these deformities are caused by a parasitic trematode, UV radiation and chemicals synergistically. Authors recommend that methoprene be the first choice for control and eradication of introduced mosquito species
Miyakawa, H., T.K. Hirakawa, O.Y. and Miyagawa, O.S. Tatarazako, T. Miura, J.K. Colbourne and T. Iguchi. 2013. A Mutation in the Receptor Methoprene-Tolerant Alters Juvenile Hormone Response in Insects and Crustaceans. Nature Communications 4, Article number: 1856doi:10.1038/14.	Most of the insects use juvenile hormone III as the innate juvenile hormone ligand. By contrast, crustaceans use methyl farnesoate. Despite this difference, the process of this ligand transition is unknown. A single amino-acid substitution in the receptor. Juvenile hormone-binding pockets of the orthologous genes differ by only two amino acids, yet a single substitution within Daphnia metabolic pathways appears to enhance the receptor's responsiveness to juvenile hormone III. These results suggest that this mutation within an ancestral insect lineage contributed to the evolution of a juvenile hormone III receptor system. This is a theoretical study and has no strong correlative response to the toxicity of methoprene.
Hurst, T.F., B.H. Kay, P.A. Ryan and M.D. Brown. 2007. Sublethal Effects of Mosquito Larvicides on Swimming Performance of Larvivorous Fish *Melanotaenia duboulayi* (Atherinoformes: Melanotaeniidae). J. Econ. Ent. 100(1):61-65.	Laboratory studies were conducted to determine the sublethal effects of exposure to the mosquito larvicides temephos, primiphos-methyl, Bti, *Bacillus sphaericus*, and methoprene. Methoprene exposures of 10 times the effective field concentration had no effect on the Australian Crimson-Spotted Rainbowfish (*Melanotaenia duboulayi*) swimming speed.

Additional Methoprene Publications Reviewed

Publication Authors	Summary of Reported Findings
Kenyon, S. and G. Kennedy. 2001. Methoprene: A Review of the Impacts of the Insect Growth Regulator Methoprene on Nontarget Aquatic Organisms in Fish Bearing Waters (ver. 2.0). Prepared for the Massachusetts Pesticide Board Subcommittee. 40pp.	Although this paper includes no new data generated by these authors, this paper is a comprehensive overview of the reported effects of methoprene on non-target organisms, especially aquatic species, including a review of the reported effects of methoprene on amphibians. The authors report several critical findings and responses based on their reviews of existing publications: 1. Results reported in most published papers do not support the contention that methoprene applications for midge and mosquito control can lead to amphibian malformations. 2. Although some reports suggest that methoprene can adversely affect crustaceans, studies indicate that impacts to crustaceans may be variable in magnitude but are not likely to adversely impact crustaceans at expected environmental concentrations. 3. The use of methoprene at appropriate application levels would be less harmful to aquatic communities than other available mosquito pesticides for mosquito control. 4. Detailed physiochemical information on methoprene, including its short half-life in the environment, challenges reports of potentially irreversible harm to the aquatic ecosystem. 5. Regulatory issues pertaining to potential uses of methoprene for mosquito control are included that are relevant for several locations and states. The reviews in this report include critiques of many of the publications that have reported adverse impacts to non-target species and the ecosystem. 6. Summaries of methoprene publications are focused on plausible and reasonable confounding factors in each study that might account for the reported effects. Several special exposure conditions are discussed that may have played a role in reported effects, such as possible salinity toxicity and additive effects of solvents and media contaminants. This report provides extensive and realistic critiques of methoprene as a pesticide for mosquito control.
Lawler, S.P., D. Dritz and T. Jensen. 2000. Effects of Sustained Release Methoprene and a Combined Formulation of Liquid Methoprene and *Bacillus thuringiensis israelensis* on Insects in Salt Marshes. Arch. Environ. Contam. Toxicol. 39:177-182.	Applications of Bti liquid (Vectobac 12AS) and the methoprene products Altosid Liquid Larvicide and Altosid Pellets near maximum label rates in a salt marsh found no detectable effects of Bti, Bti and methoprene (duplex), or methoprene pellets on nontarget saltmarsh insects. Rates used were 13.68 oz. Bti/acre, 6.09 oz. liquid methoprene/acre, and 9.28 lb methoprene pellets per acre. All pesticides effectively controlled the salt marsh mosquito *Aedes dorsalis*.

Additional Methoprene Publications Reviewed

Publication Authors	Summary of Reported Findings
McKenney, C.L. 2005. The Influence of Insect Juvenile Hormone Agonists on Metamorphosis and Reproduction in Estuarine Crustaceans. Integr. Comp. Biol. 45:97-105.	Comparative developmental and reproductive studies were performed on several species of estuarine crustaceans in response to three juvenile hormone agonists (pyriproxyfen, methoprene and fenoxycarb). Claims that larval development of the grass shrimp, *Palaemonetes pugio*, was greater than two orders of magnitude more sensitive to disruption by methoprene and fenoxycarb than was embryonic development. Developing larvae of the mud crab, *Rhithropanopeus harrisii*, exhibited reduced metamorphic success at lower concentrations of methoprene (100 ppb) and pyriproxyfen (50 ppb) than grass shrimp larvae (1000 ppb and 100 ppb respectively). The final crab larval stage, the megalopa, was more sensitive to methoprene and fenoxycarb exposure than earlier zoeal stages. Juvenile mysids (*Americamysis bahia*) released by exposed adults and reared through maturation without further exposure produced fewer young and had altered sex ratios (lower percentages of males) at lower parental-exposure concentrations than directly affected parental reproduction. These findings support a recommendation to use a functional approach (expanding the test base) as an appropriate screening procedure to evaluate potential environmental endocrine-disrupting chemicals in aquatic environments.
Olmstead, A. and G. LeBlanc. 2003. Insecticidal Juvenile Hormone Analogs Stimulate the Production of Male Offspring in the Crustacean *Daphnia magna*. Environ. Health Perspect. 111(7):919-924.	Juvenile hormone analogs (JHAs) represent a class of insecticides that were designed specifically to disrupt endocrine-regulated processes relatively unique to insects. Earlier report by these authors suggested that the crustacean juvenoid hormone methyl farnesoate (MF) at high levels (50 ppb) can initiate development of oocytes of crustacean Daphnia magna to develop into males. Authors suggest that insecticidal JHAs might mimic the action of MF to produce altered sex ratios of offspring. Daphnids were exposed continuously (3 weeks) to sublethal concentrations of MF, the JHA pyriproxyfen, and several non juvenoid chemicals to discern whether excess male offspring production is a generic response to stress or a specific response to juvenoid hormones. This response was not elicited by methoprene exposure.

Additional Methoprene Publications Reviewed

Publication Authors	Summary of Reported Findings
Olmstead, A. and G. LeBlanc. 2001. Temporal and Quantitative Changes in Sexual Reproductive Cycling of the Cladoceran *Daphnia magna* by a Juvenile Hormone Analog. J. Exp. Zool. 290:148-155.	Cyclic parthenogens, such as the cladoceran, *Daphnia magna*, utilize both asexual (parthenogenetic) and sexual reproduction. Experiments were conducted with the juvenile hormone analog methoprene to test the hypothesis that members of the insect juvenile hormone/vertebrate retinoic acid family of transcription factors are involved in the regulation of sexual reproduction in daphnids. Neither methoprene food reduction, nor crowding independently stimulated entry into the sexual reproductive phase of the daphnids. However, the combination of food deprivation and crowding stimulated entry into the sexual reproductive phase characterized by an initial high production of males and the subsequent intermittent production of haploid egg-containing ephippia. Exposure to 160 nM methoprene (50 ppb) along with food deprivation and crowding caused a significant reduction in the percentage of males produced during the early phase of the sexual cycle and significantly increased the percentage of males produced during the later stages of the cycle. Methoprene concentrations as low as 6.4 nM (2 ppb) reduced the number of resting eggs produced and proportionately increased the production of parthenogenetically-produced neonates. These experiments demonstrate that methoprene may uncouple the coordinated production of males and resting eggs during the sexual reproductive period of *D. magna* at the levels tested Methoprene, at these concentrations, which are higher than typical application rates is said to stimulate male offspring production and defers their production to latter stages of the sexual reproductive period, while inhibiting the production of resting eggs and promoting the continuance of parthenogenetic reproduction
Olmstead, A. and G. LeBlanc. 2001. Low Exposure Concentration Effects of Methoprene on Endocrine Regulated Processes in the Crustacean *Daphnia magna*. Toxicol. Sciences. 62:268-273.	Methoprene may exert toxicity to crustaceans by mimicking or interfering with methyl farnesoate, a crustacean juvenoid. The authors suggest that methoprene interferes with endocrine-regulated processes in crustaceans by several mechanisms involving agonism or antagonism of juvenoid receptor complexes. In this present study, characterizing response curves for methoprene for endpoints related to development and reproduction of the crustacean *Daphnia magna* resulted in response thresholds at approximately 4 ppb, considerably higher than would be used in actual field scenarios. Molt frequency was reduced by methoprene in a concentration-dependent manner, at 4.2 nM (1.3 ppb) and a NOEC of 32 nM (9.9 ppb). Results in the study suggest that methoprene may elicit some toxicity to endocrine-related processes in the 5–50 nM (6 to 16 ppb) concentration range.

Additional Methoprene Publications Reviewed

Publication Authors	Summary of Reported Findings
Rexrode, M., I. Abdel-Saheb and J. Andersen. 2008. Potential Risks of Labeled S-Methoprene Uses to the Federally Listed California Red-Legged Frog. Pesticide Effects Determination. U.S. EPA Biopesticide and Pollution Prevention Division. 77pp.	Based on the results of this reported assessment, the following hypotheses can be **rejected**: > The labeled use of S-methoprene impacts growth and viability of juvenile and adult CRLFs. causing mortality or by adversely affecting growth or fecundity: > indirect effects occur by reducing or changing the composition of food supply; > indirectly affects critical habitat by reducing or changing the composition of the aquatic plant community in the ponds and streams comprising the species' current range and designated critical habitat, thus affecting primary productivity and/or cover; > indirectly affects critical habitat by reducing or changing the composition of the terrestrial plant community (i.e., riparian habitat) and habitat in the ponds and streams comprising the species' current range and designated critical habitat; > modifies critical habitat changing breeding and non-breeding aquatic habitat (via modification of water quality parameters, habitat morphology, and/or sedimentation); > modifies the designated critical habitat of the CRLF by reducing the food supply required for normal growth and viability of juvenile and adult CRLFs; > modifies the designated critical habitat of the CRLF by reducing or changing upland habitat within 200 ft of the edge of the riparian vegetation necessary for shelter, foraging, and predator avoidance. > modifies the designated critical habitat of the CRLF by reducing or changing dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites that do not contain barriers to dispersal. > modifies the designated critical habitat of the CRLF by altering chemical characteristics necessary for normal response line, having a threshold of 12.6 nM (4 ppb). The conclusion is that there is a "may affect", but "not likely to adversely affect" determination for the CRLF from exposures to S-methoprene at levels above 4ppb (much higher than actual exposure when s-methoprene is used per the label for mosquito control.

Additional Methoprene Publications Reviewed

Publication Authors	Summary of Reported Findings
Russell, T., B. Kay and G. Skilleter. 2009. Environmental Affects of Mosquito Insecticides on Saltmarsh Invertebrate Fauna. Aquatic Biology 6:77-90.	The effects of Bti and s-methoprene on nontarget aquatic and terrestrial fauna in 2 subtropical saltmarshes approximately 30 km apart are reported. Application rates used were 16.42 oz. Bti per acre and 4.93 oz. methoprene (Altosid Liquid Larvicide) which is slightly in excess of the maximum label rate. The main taxa collected from ephemeral pools were copepods and from terrestrial plots were springtails (*Collembola*), mites (*Acariformes*) and ants (*Hymenoptera*), with smaller numbers of beetles (*Coleoptera*), true bugs (*Heteroptera*) and flies (*Diptera*). Following applications of both products, inconsistent short-term (<20 d) differences in the composition of the arthropod community were noted. After applications of Bti to ephemeral pools, smaller numbers of copepods were recorded at only one locality and the difference was not significant. There were no significant effects of s-methoprene on the arthropods in ephemeral pools at either locality. There were few significant effects on any other taxa and these effects were also localized and short-lived. These results suggest that applications of s-methoprene do not impact the abundance and composition of nontarget arthropod assemblages in typical subtropical saltmarshes.
Sparling, D. 2000. Effects of Altosid and Abate-4E on Deformities and Survival in Southern Leopard Frogs Under Semi-Natural Conditions. J. Iowa Acad Sci. 107(3):90-91.	Experimental wetlands were sprayed with Abate-4E (a.i. temephos) and Altosid (a.i. methoprene) through the summer “following label directions" Tadpoles captured from ponds sprayed with Altosid had a 15% deformity rate mostly involving total or partially missing hind limbs. Tadpoles from control ponds had a 5% rate of deformities. The difference was statistically significant. The relative abundance of tadpoles from ponds sprayed with Abate-4E was significantly lower than those from Altosid-sprayed or control wetlands. This project was conducted with high concentrations of methoprene products to illicit these responses. Comparison of temephos and methoprene indicate that methoprene exposure at label rate did not illicit adverse effects.
Stueckle, T.A., J. Likens and C.M. Foran. 2009. Limb Regeneration and Molting Processes Under Chronic Methoprene Exposure in the Mud Fiddler Crab, *Uca pugnax.* Comp. Biochem. Physiol. Part C. 147:366-377.	This study evaluated the effect chronic methoprene exposure would have on male and female fiddler crab, *Uca pugnax*, limb regeneration and molting. Crabs were chronically exposed to methoprene (dissolved in acetone) concentrations of 0, 0.1, 1.0, 10, 100 and 1000 µg/L (0-1000 ppb). The authors found male crabs lost more weight per body volume than females, took longer to proceed through proecdysis when exposed to 0.1 µg/L methoprene, and exhibited elevated frequency for abnormal limb formation at 1.0 µg/L. Female crabs displayed no such trend. Methoprene also did not significantly alter extractable exoskeleton protein or chitin content, although variable water-soluble protein expression increased with exposure at 1.0 µg/L. The authors suggest that adult male *Uca pugnax* possess greater sensitivity to chronic methoprene exposure during limb regeneration and molting. The authors also point out that the daily pulsed methoprene exposure used in this study may over estimate real world exposure rates since known slow-release methoprene applications result in pulse frequencies ranging every 2-19 days with low to negligible levels between pulses.

Additional Methoprene Publications Reviewed

Publication Authors	Summary of Reported Findings
Stueckle, T.A. 2008. An Evaluation of the Non-Target Effects of Mosquito Control Pesticides on *Uca pugnax* Physiology, Limb Regeneration and Molting Processes. Dissertation submitted to Eberly College of Arts and Sciences at West Virginia University.	This study addresses the potential effects of methoprene and permethrin on physiology, limb regeneration and molting ability of a crustacean species, *Uca pugnax*. The author claims that chronic methoprene exposure at environmental concentrations may cause increased male abnormal regenerative limbs and delays in proecdysis. Both male and female crabs displayed increased variability in water-soluble exoskeleton protein. Results presented link both chemical and salinity regimes to potential harmful effects. The study also focuses on some of the possible additive effects of chemicals and media salinity as additive stressors (permethrin, methoprene and salinity). Concentrations of methoprene used in this study were between label rates for mosquito control to approximately 2.5 to 3X possible exposures based on label rates. The author reports that "most observations were no effect for methoprene alone. The study revealed no significant effects until the other test stressors (permethrin and salinity) were added and tested, suggesting that exposure of *Uca pugnax* to methoprene alone did not result in any significant adverse effects. In addition, males displayed some minor methoprene and permethrin non-additive effects on total exoskeleton protein content, reduced body mass gain, reduced carapace width gain and overall body condition loss. Females displayed only reduced carapace size gain and increased respiration rate, possibly due to increased metabolic and biotransformation of both pesticides. This report suggests that these results, although not significant, indicate that insect growth regulators, pyrethroid insecticides or their mixture into coastal wetland environments may pose a potential risk to crustaceans.
Walker, A., P. Bush, J. Puritz, T. Wilson, E.S. Chang, T. Miller, K. Halloway and M.N. Horst. 2005. Bioaccumulation and Metabolic Effects of the Endocrine Disruptor Methoprene in the Lobster, *Homarus americanus*. Integr. Comp. Biol. 45(1):118-126.	Methoprene has *suspected* toxic effects on larval and adult crustaceans reported recently for lobsters. These studies report the effects of continuous exposures of methoprene on larvae and adults. Low levels of methoprene had adverse effects on stage II lobster larvae at 1 ppb. Stage IV larvae were more resistant, but did exhibit increases in molt frequency beginning at exposures of 5 ppb. Juvenile lobsters exhibited variations in tissue susceptibility to methoprene pathway of lobster cuticle synthesis and the quality of the post-molt shell. It is likely that a combination of factors led to the reported reduced lobster population.

Additional Bti Publications Reviewed

Publication Authors	Summary of Reported Findings
Ali, A., R.J. Lobinske, R.J. Leckel, N Carandang, and A. Mazumdar. 2008. Population Survey and Control of Chironomidae (Diptera) in Wetlands in Northeastern Florida, USA. Florida Entomologist 91(3):446-452.	Two species of Chironomids, *Glyptotendipes paripes* and *Goeldichironomus carus* in Florida wetlands were evaluated for sensitivity to Temephos and Bti and s-methoprene. This paper reviews the comparison of these larvicides both for efficacy and in cost. The summary of the paper suggests that Bti and s-methoprene be used in rotation with Tim FR's for Midge control. The authors suggest that this rotation approach in an IPM technique would have only temporary and reversible impact on nontarget biota. However, the study did not actually evaluate nontargets in the field as part of the study. Rates of Bti used were 2.07 and 4.14 times maximum mosquito control label rates and achieved 52% and 88% reduction of adult emergence in experimental field plots.
Becker, N. 1998. The Use of *Bacillus thuringiensis* subsp. *israelensis* (Bti) Against Mosquitoes, With Special Emphasis on the Ecological Impact. Israel Journal of Entomology. 32:63-69.	Overview report on the use of Bti *Bacillus thuringiensis israelensis* products in Germany and information about the lack of adverse effects resulting from treatments. The author indicates that more than 200 tons of Bti is used annually worldwide without any evidence of harmful impact on the environment. In Germany, 97 cities and municipalities along a 310 kilometer stretch of the Upper Rhine River, with a total population of 2.5 million people, have treated areas to control mosquitoes, mainly the flood-water mosquito *Aedes vexans*, over a breeding area of some 600 km^2 of the Rhine's flood-plain. The control of Aedes mosquitoes in Germany is based solely on the use of Bti products. Precise mapping of the breeding sites accounts not only for the mosquito population but also wide ecological considerations. For instance, from 1981 to 1996 approximately 37 tons of Bti powder or almost 1,000 tons of Bti granules as well as 29 tons of Bti liquid concentrates have been used in Germany, treating over 1,000 km2 of breeding area, resulting in a reduction of the mosquito population by more than 90%. In an extensive monitoring program the environmental safety of Bti treatments is confirmed for each routine treatment. All investigations have shown that the numbers of *Aedes* mosquitoes are drastically reduced but that all other insects continue to develop in the water and provide, as winged adults, a food resource for birds, amphibians and bats.
Boissvert, M. and J. Boisvert. 2000. Effects of *Bacillus thuringiensis* var. *israelensis* on Target and Nontarget Organisms: A Review of Laboratory and Field Experiments. Biocontrol Science and Technology 10:517-561.	An extensive review of the literature was conducted concerning toxicity, mode of action, environmental fate, factors affecting efficacy, and effects on nontarget organisms for the biopesticide Bti (*Bacillus thuringiensis* var. *israelensis*). The majority of this review emphasizes nontarget impacts, analyzing the results of 75 studies covering 125 families, 300 genera and 400 species of target and nontarget organisms. Overall, formulations of Bti used at the label rates for mosquito control do not have a significant impact on most other animals or plants. It was however suggested that under different application conditions, the effects of Bti may be hard to predict. It was further suggested that high frequencies of application and/or over dosages of Bti against mosquitoes may result in some persistence of the toxic crystals, which could have potential adverse effects on the food web. It was recommended that more long-term and controlled studies be performed to better ascertain any potential food web effects that may occur with prolonged use and repeated applications of Bti.

Additional Bti Publications Reviewed

Publication Authors	Summary of Reported Findings
Brown, M., D. Thomas, P. Mason, J.G. Greenwood and B.H. Kay 1998. Laboratory and Field Evaluation of the Efficacy of Four Insecticides for *Aedes vigilax* (Diptera: Culicidae) and Toxicity to the Nontarget Shrimp *Leander tenuicornis* (Decapoda: Palaemonidae). J. Econ. Ent. 92(5):1045-1051.	This report describes laboratory and field tests of the toxicity of two organophosphate compounds (temephos and pirimiphosmethyl) and methoprene and *Bacillus thuringiensis* ssp*. israelensis*.to a saltwater mosquito (*Aedes vigilax*) including an evaluation of the selectivity for the mosquito and possible toxicity to a non-target shrimp *Leander tenuicornis* (a Decapod). In addition to developing LC 50 values the report includes measures of selectivity of each pesticide for the target organisms versus nontarget. The Bti applications were highly toxic to the saltwater mosquito while not affecting survival of the shrimp that inhabit the same saltwater marsh areas in the study. In addition, Bti did not affect water quality. The authors suggest that Bti is "ideal for continued control of *Ae. vigilax* in Australian saltwater ponds".
Cao, C., L. Sun, R. Wen, X. Li, H. Qu and Z. Wang. 2012. Toxicity and Affecting Factors of *Bacillus thuringiensis* var. *israelensis* on *Chironomus kiiensis* Larvae. J. Insect Sci. 12(article 126):1-8.	*Bacillus thuringiensis* var. *israelensis* (Bti). Laboratory bioassays were used to study toxicity and affecting factors of Bti on *Chironomus kiiensis* larvae using three commercial Bti formulations (oil miscible suspension, 1,200 ITU/mL (1gm); wettable powder, 1,200 ITU/mg (1gm); technical material, 5,000 ITU/mg, (4 gm) of Bti). The toxicity of Bti formulations to third and fourth instar *C. kiiensis* larvae was in decreasing order of technical material, oil miscible suspension, and wettable powder, based on the 12 and 24 hour LC50 values. Increasing larval densities (from 10 to 30 per bioassay cup) increased the LC50 values for fourth instar *C. kiiensis* larvae. The LC50 values for fourth instar larvae reared in sand substrate were higher than those from soil substrate, and autoclaved substrates significantly increased the LC50 values. The technical material of Bti at 12 and 24 hours responded similarly to changes in temperature between 30°C and 15°C, but the LC50 values at a range of tested temperatures showed distinct differences in time points. Study provided a comparison of efficacy of Bti formulations but no report on non-target effects in this article.
Caquet, T., M. Roucaute, P. Le Goff and L. Lagadic. 2011. Effects of Repeated Field Applications of Two Formulations of *Bacillus thuringiensis* var. *israelensis* on Nontarget Saltmarsh Invertebrates in Atlantic Coastal Wetlands. Ecotoxicology and Env. Safety. 74(5):1122-1130.	A 2-year controlled study on French Atlantic coastal saltmarsh wetlands was conducted to evaluate the effects of multiple applications of Bti. No adverse effects of the treatments were shown on the abundance of midge larvae, suggesting that the availability of these food sources for birds was not negatively affected by Bti applications. It was concluded that, as currently performed in Western France coastal wetlands, land-based treatments of saltmarsh pools for larval mosquito control with *Bti did not adversely impact nontarget aquatic invertebrate communities*. Near minimum mosquito control label rates for the Bti products Vectobac 12AS and Vectobac WG were utilized in this study.
Craggs, R., L. Golding, S. Clearwater, L. Susaria and W. Donovan. 2005. Control of Chironomid Midge Larvae in Wastewater Stabilization Ponds: Comparison of Five Compounds. Water Sci. Tech. 51(12):191-199.	The efficacy of Maldison, an organophosphate insecticide, was compared to *Bacillus thuringiensis* var. *israelensis* (Bti), methoprene, pyriproxyfen, and diflubenzuron. During 21-day small-scale trials, Bti, diflubenzuron and Maldison reduced live larval numbers by 80-89% compared to controls and adult emergence was markedly reduced by all compounds (72-96%). Large-scale trials with Bti (Vectobac WG) powder at 10 kg total ingredient/ha (to give a final concentration in the water column of 1000 µg/L) resulted in a slight reduction in midge larval numbers compared to controls and had little effect on adult emergence.
Davis, R.S. and R.K.D. Peterson. 2008. Effects of Single and Multiple Applications of Mosquito Insecticides on Nontarget Arthropods. J. Amer. Mosq. Cont. Assoc. 24(2):270-280.	Experiments were conducted to assess the acute impacts of mosquito adulticides (permethrin and d-phenothrin) and larvicides (*Bacillus thuringiensis israelensis* and methoprene) on nontarget aquatic and terrestrial arthropods after a single application. The first experiment was conducted in 2004 and 2005 with Bti on nontarget terrestrial arthropods after a single application. For aquatic samples, no overall treatment effects of Bti were observed. In general, nearly all of the responses evaluated in this study indicated few, if any, deleterious effects from Bti application.

Additional Bti Publications Reviewed

Publication Authors	Summary of Reported Findings
Duchet, C., M. Coutellec, E. Franquet, C. Lagneau and L. Lagadic. 2010. Population-Level Effects of Spinosad and *Bacillus thuringiensis israelensis* in *Daphnia pulex* and *Daphnia magna*: Comparison of Laboratory and Field Microcosm Exposure Conditions. Ecotoxicology, 19(7):1224-1237.	Use of a life table response approach to assess population-level effects of two insecticides used against mosquito larvae, spinosad (8 µg/l) and *Bacillus thuringiensis* var. *israelensis* (Bti, 0.5 µg/l), on two nontarget species, *Daphnia pulex* and *Daphnia magna* (Crustacea: Cladocera), under laboratory versus field microcosms conditions. In laboratory conditions, these theoretical calculations and analyses performed for each species suggests a negative effect of spinosad on survival, mean time at death, and fecundity as compared to controls and Bti-treated groups; for both species, population growth rate λ was lower under exposure to spinosad. In field microcosms, 2 days after larvicide application, differences in population growth rates were observed between spinosad exposure conditions, and control and Bti exposure conditions. Simulations performed on spinosad-exposed organisms led to population "extinction. *D. magna* was shown to be more sensitive than *D. pulex* to spinosad in the laboratory, and the effects were also detectable through field population demographic simulations.
Eder, E. and I. Schönbrunner, 2010. Toxicity of *Bacillus thuringiensis israelensis* on the Nontarget Organisms *Triops cancriformis*, *Branchipus schaefferi*, *Leptestheria dahalacensis* (*Crustacea*: *Branchiopoda*: *Notostraca*, *Anostraca*, *Spinicaudata*). The Open Environmental Pollution & Toxicology Journal. 2:16-20.	Authors report that in a blind and randomized study, early post-larval stages of the tadpole shrimp *Triops cancriformis*, the fairy shrimp *Branchipus schaefferi*, and the clam shrimp *Leptestheria dahalacensis* were exposed to different concentrations of a commonly available Bti suspension, equivalent to 0, 4.5 (recommended treatment concentration), 45, 450, and 4500x (related to the recommended level). No statistically significant correlations were found between Bti concentration and mortality or longevity of the examined organisms at any of the exposure levels studied.
Frouz, J., R.J. Lobinske, A. Yaqub and A. Ali. 2007. Larval Gut pH Profile in *Pestiferous Chironomus crassicaudatus* and *Glyptotendipes paripes* (Chironomidae: Diptera) in Reference to the Toxicity of *Bacillus thuringiensis serovar israelensis*. J. Amer. Mosq. Cont. Assoc. 23(3):355-358.	Gut pH was measured in the 4th-stage larvae of two chironomid species, *Chironomus crassicaudatus* and *Glyptotendipes paripes*. The gut pH in both species was close to neutral, varying from 6.7 to 7.4 and 6.9 to 7.6 pH units for *C. crassicaudatus* and *G paripes*, respectively. The gut pH in both chironomid species remained between pH values of 5.5 and 7. The pH profiles in these 2 species of chironomids are lower than for mosquitoes or Lepidoptera larvae. The authors suggest that this could be the reason for the relatively lower susceptibility of chironomid larvae to *Bacillus thuringiensis serovar israelensis* toxin proteins than some other nematoceran Diptera, specifically mosquitoes.
Stark, J.D.. 2005. A Review and Update of the Report "Environmental and Health Impacts of *Bacillus thuringiensis israelensis*" 1998 by Travis R. Glare and Maureen O'Callaghan. Report for the New Zealand Ministry of Health. 32pp.	Much of the new literature on nontarget effects still indicates that Bti is one of the least environmentally damaging pesticides used for mosquito control. Some reports have shown that large declines in insect biomass can occur after long-term use of Bti in freshwater wetlands. However, the authors indicate that no evidence for permanent damage to ecosystem function has been found. Organisms that utilized insects for food, adapted to the declines and either switched to other food sources or travelled (birds) outside of the treated zones to acquire insects. The authors suggest that the conclusions reached by Glare and O'Callaghan in 1998 (no significant impact of Bti on critical food sources) are valid and that Bti be used for control and eradication of introduced mosquito species (with rotation of methoprene). The authors justify their recommendation because they argue that alternative control agents, other than *Bacillus sphaericus*, are OP insecticides that are broad-spectrum neurotoxins that may pose a higher risk to the environment, human, and animal health than Bti.

Additional Bti Publications Reviewed

Publication Authors	Summary of Reported Findings
Hurst, T.P., B.H. Kay, P.A. Ryan, and M.D. Brown. 2007. Sublethal Effects of Mosquito Larvicides on Swimming Performance of Larvivorous Fish *Melanotaenia duboulayi* (Atheriniformes: Melanotaeniidae). J. Econ. Ent. 100(1):61-65.	Laboratory studies were conducted to determine the sublethal effects of exposure to the mosquito larvicides temephos, primiphos-methyl, Bti, *Bacillus sphaericus*, and methoprene. Bti exposures of 10 times the effective field concentration had no effect on the Australian Crimson-Spotted Rainbowfish (*Melanotaenia duboulayi*) swimming speed.
Lagadic. L. M. Roucaute and T. Caquet. 2014. Bti Sprays do not Adversely Affect Nontarget Aquatic Invertebrates in French Atlantic Coastal Wetlands. J. Applied Ecology. 51(1):102-113	This was a 6-year study sampling invertebrates in the water and sediment of control and Bti treated saltmarsh pools. Taxa abundance was the metric used along with physicochemical parameters in the same pools so that homogeneity of environmental conditions between the control and treated areas could be tested*. It was concluded that long-term use of Bti in coastal wetlands had no influence on the temporal evolution of the taxonomic structure and taxa abundance of nontarget aquatic invertebrate communities*, *(which is highly driven by abiotic factors).* In addition, over the long term, the amount of invertebrates that could be used as food resources by birds was maintained in Bti-treated areas. Subtle differences in the range of variation of abiotic factors result in discrepancies between control and treated area in terms of invertebrate abundance, which could be wrongly attributed to Bti.
Laurence, D., L. Christophe and F. Roger. 2012. Using the Bio-Insecticide *Bacillus thuringiensis israelensis* in Mosquito Control. www.intechopen.	This article provides an extensive and comprehensive review of the Bti formulations and use scenarios over the last few decades. Excellent source of the Bti background papers. General overview of several issues and information such as environmental factors affecting efficacy, effects on nontarget organisms, effects on ecosystems, managing mosquito resistance, and use with other bio-insecticides.
Lawler, S.P., D. Dritz and T. Jensen. 2000. Effects of Sustained Release Methoprene and a Combined Formulation of Liquid Methoprene and *Bacillus thuringiensis israelensis* on Insects in Salt Marshes. Arch. Environ. Contam. Toxicol. 39:177-182	Applications of Bti liquid (Vectobac 12AS and the methoprene products Altosid Liquid Larvicide and Altosid Pellets near maximum label rates in a salt marsh found no detectable effects of Bti, Bti and methoprene (duplex), or methoprene pellets on nontarget saltmarsh insects. The rate of Bti used was 13.68 oz./acre, which was also an effective for controlling the salt marsh mosquito *Aedes dorsalis*.
Liber, K., K.L. Schmude and D. Rau. 1998. Toxicity of *Bacillus thuringiensis* var. *israelensis* to Chironomids in Pond Mesocosms. Ecotox. 7(6):343-354.	A pond mesocosm wetland study was conducted to evaluate the potential toxicity of *Bacillus thuringiensis* var. *israelensis* to chironomids. Bti was applied to three replicate mesocosms for each of five applications rates (2.4, 8, 20, 40 and 80 lbs/acre), with the base application rate being 8 lbs/acre. The abundance of Chironomid larvae was significantly reduced at the 10x base rate treatment at 4 d. Chironomid abundance was reduced after a second application with 10x base rate, but recovered within 32 d. The abundance of Orthocladiinae larvae was significantly reduced at both the 10x and 5x base rate treatments, whereas the Tanypodinae appeared unaffected by all treatments, but no reductions were statistically significant. Emergence of adult Chironomidae was significantly reduced at the 10x base rate. Emergence of Ceratopogonidae and Chaoboridae was unaffected by all Bti treatments. The maximum mosquito control label rate for the formulation of Bti granules used in this study is 20 lb/acre.

Additional Bti Publications Reviewed

Publication Authors	Summary of Reported Findings
Lundstrom, J.O., Y. Brodin, M.L. Schafer, T.Z.P. Vinnersten and O. Ostman. 2010. High Species Richness of Chironomidae (Diptera) in Temporary Flooded Wetlands Associated with High Species Turnover Rates. Bull. Ent. Res. 100(4):433-444.	Species richness and species turnover of Chironomidae was studied in irregularly flooded wetlands of the River Dalälven flood-plains in central Sweden. Recurrent irregular floods may have induced high chironomid species richness. Half of the wetlands were treated with *Bacillus thuringiensis* var. *israelensis* (Bti) against larvae of the flood-water mosquito *Aedes sticticus*. These treatments had no significant effect on chironomid species richness, but there was a higher species turn-over between years of primarily low abundance species in the treated wetlands. The cumulative number of species was also higher in the Bti-treated experimental wetlands than in the untreated reference wetlands. Bti treatment appeared to have only small effects on chironomid species richness possibly due to a compensatory increase of the colonization-extinction dynamics.
Lundstrom, J.O., M.L. Schafer, E. Peterssen, T.Z.P. Vinnersten, J. Landin and Y. Brodin. 2009. Production of Wetland Chironomidae (Diptera) and the Effects of Using *Bacillus thuringiensis israelensis* for Mosquito Control. Bull. Ent. Res. 100(1):117-125.	*Bacillus thuringiensis* var. *israelensis* (Bti) is used to control immature mosquitoes in Sweden. Six years of monitoring Chironomidae, a nontarget organism, was conducted in three wetlands with Bti-treatment against mosquitoes and in three wetlands without treatment. Moderately high label rates (11.6 to 13.4 lbs/acre of the product Vectobac G (a corncob granule) were used. Emergence traps were used for continuous insect sampling. A total of 21,394 chironomids of 135 species were collected. No reduced production of chironomids was found, neither family nor subfamily level, in Bti-treated as compared to untreated wetlands. Four species had higher and one species had lower production in treated areas. Bti-based control of floodwater mosquitoes does not cause any major direct negative effects on chironomid production, and therefore does not induce any risk for indirect negative effects on birds, bats or any other predators feeding on chironomids.
Mezzomo, B.P., A.L. Miranda-Vilela, I.S. Freira, L.C.P. Barbosa, F.A. Portilho, Z.G.M. Lacava and C.K. Grisolia. 2013 Hematotoxicity of *Bacillus thuringiensis* as Spore-crystal Strains Cry1Aa, Cry1Ab, Cry1Ac or Cry2Aa in Swiss Albino Mice. J. Hematol. Thromb. Dis. 1:104 doi: 10.4172/2329-8790.1000104	Albino mice blood parameters were evaluated after gavage with a single dose of prepared Bt proteins as 27 mg/ Kg, 136 mg/Kg or 270 mg/Kg, 24 h, 72 h or 7 days before euthanasia. Binary combinations of these four spore-crystal proteins were also assayed at 270 mg/Kg with a single administration 24 h before euthanasia. Hematotoxicity evaluations of blood samples were conducted using an automated hematology analyzer and with a micronucleus test for genotoxicity analysis in mice bone marrow cells. Spore-crystal administrations provoked selective hematotoxicity for erythroid lineage. Reduction in bone marrow cell proliferation was seen but no genotoxic effects. Similar results were observed for binary combinations at 24 h, suggesting that further studies are required to clarify the mechanism involved in the hematotoxicity found in mice, and to establish the toxicological risks to nontarget organisms, especially mammals.

Additional Bti Publications Reviewed

Publication Authors	Summary of Reported Findings
Negri, A.P., R. M. Soo, F. Flores, N. S. Webster. 2009. *Bacillus* insecticides are not Acutely Harmful to Corals and Sponges. Mar. Ecol. Prog. Ser. 381:157-165.	*Bacillus thuringiensis* is widely considered an environmentally safe insecticide to control mosquitoes and a number of agriculture pests. Bacteria closely related to *B. thuringiensis* have recently been discovered in association with diseased sponges, which has raised concerns that *Bacillus* insecticides may be harmful to tropical marine invertebrates. Coral larvae and juvenile corals were exposed to the insecticides VectoBac® G (containing *B. thuringiensis israelensis*) and VectoLex® G (containing *B. sphaericus*) at concentrations up to 100 fold higher than concentrations that affect target immature mosquitoes. VectoBac G and VectoLex G had no effect on the survival and metamorphosis of *Acropora millepora* and *A. tenuis* larvae *at very high concentrations (5000 µg l^{-1}*). The juvenile corals of the same species were also unaffected after four sequential 48 h exposures to *B. thuringiensis israelensis* and *B. sphaericus* at different stages of development. Adult corals (*A. millepora*) and sponges (*Ianthella basta*) were exposed to a single 6 h pulse of 1000 µg l^{-1} VectoBac G. No evidence of coral or sponge disease was observed during the following 2 wk. These results indicate that insecticides containing *Bacillus* spp. are unlikely to be acutely pathogenic to corals and sponges.
Ostman, O., J.O. Lundstrom, and T.Z.P. Vinnersten. 2008. Effects of Mosquito Larvae Removal with *Bacillus thuringiensis israelensis* (Bti) on Natural Protozoan Communities. Hydrobiologia 607(1):231-235.	Mosquito larvae are considered important predators on protozoans and bacteria, and this study addresses a result of a reduction of mosquito larvae density in natural wetlands caused by application of Bti may indirectly affect these microbial communities. Six natural wetlands were used to illustrate that the densities of heterotrophic protozoans was on an average 4.5 times higher in wetland areas treated with Bti than in control areas. In addition, the taxonomic richness of heterotrophic protozoans increased on an average of 60% in areas with Bti application compared to control areas. The increase in protozoan density and richness was fairly consistent among sites of different wetland habitats, indicating a potential positive, but indirect effect of treatments.
Poopathi, S. and S. Abidha. 2010. Mosquitocidal Bacterial Toxins (*Bacillus sphaericus* and *Bacillus thuringiensis serovar israelensis*): Mode of Action, Cytopathological Effects and Mechanism of Resistance. J. Physiol. Pathophysiol. 1(3):22-38.	This paper provides a general overview and test data discussing the use of Bs and Bti (*Bacillus sphaericus* and *Bacillus thuringiensis* serovar *israelensis*): to provide effective alternatives to broad spectrum larvicides in many situations with little or no environmental impact. New recombinant bacteria are as potent as many synthetic chemical insecticides yet are less prone to resistance, as they typically contain a mixture of endotoxins with different modes of action.
Poulin, B. 2012. Indirect Effects of Bioinsecticides on the Nontarget Fauna: The Camargue Experiment Calls for Future Research. Acta Oecologia 44:28-32.	Birds from natural and human-inhabited areas were used as model species to assess trophic impacts that may have been caused by three years of Bti applications to a monitoring region. The author reports some significant effects of Bti spraying on abundance of reed-dwelling invertebrates serving as food to passerines, as well as on the diet and breeding success of house martins nesting in rural estates and small towns. This report supports several other studies that have reported adverse food web impacts (indirect effects) as a result of the Bt applications. Although these field studies are impacted by several confounding (non-chemical) impacts, the author suggests that these results are important in the context of indirect effects of spray applications.

Additional Bti Publications Reviewed

Publication Authors	Summary of Reported Findings
Poulin, B., G. Lefebvre and L. Paz. 2010. Red Flag for Green Spray: Adverse Trophic Effects of Bti on Breeding Birds. J. Applied Ecology 47(4):884-889.	Study of food web interactions in the field with *Bacillus thuringiensis israelensis* (Bti) applications at 34.21 oz. per acre, which is slightly above maximum label rates for mosquito control. Breeding house martins *Delichon urbicum* were used as a model species to test the effect of Bti spraying on foraging rates and chick diet prior to and during 3 years of Bti spraying in the Camargue, France. Intake of Nematocera (Diptera sub-order including midges and mosquitoes) and their predators (spiders and dragonflies) were reported to be decreased significantly at treated sites, concurrently with increased flying ant intake. Clutch size and fledgling survival were lower at treated sites relative to control. Breeding success was positively correlated with intake of Nematocera and their predators at the nest level. No previous study has provided compelling evidence of Bti affecting vertebrate populations following the suppression of prey species. Indirect effects caused by repeated application of Bti through food web interactions warrant more attention.
Russell, T., B. Kay and G. Skilleter. 2009. Environmental Affects of Mosquito Insecticides on Saltmarsh Invertebrate Fauna. Aquatic Biology 6:77-90.	The effects of Bti and s-methoprene on nontarget aquatic and terrestrial fauna in 2 subtropical saltmarshes approximately 30 km apart are reported. Application rates used were 16.42 oz. Bti per acre and 4.93 oz. methoprene (Altosid Liquid Larvicide) which is slightly in excess of the maximum label rate. The main taxa collected from ephemeral pools were copepods and from terrestrial plots were springtails (*Collembola*), mites (*Acariformes*) and ants (*Hymenoptera*), with smaller numbers of beetles (*Coleoptera*), true bugs (*Heteroptera*) and flies (*Diptera*). Following applications of both products, inconsistent short-term (<20 d) differences in the composition of the arthropod community were noted. After applications of Bti to ephemeral pools, smaller numbers of copepods were recorded, but at only one locality, and the difference was not significant. There were few significant effects on any other taxa and these effects were also localized and short-lived. These results suggest that applications of Bti and s-methoprene do not impact the abundance and composition of nontarget arthropod assemblages in subtropical saltmarshes, although more work is needed on potential sub-lethal effects on the communities studied.
Siegel, J.P. 2001. The Mammalian Safety of *Bacillus thuringiensis* Based Insecticides. J. Invert. Pathol. 77:13-21.	This is a short review paper. Numerous laboratory studies have demonstrated that *Bt* and *Bt* products are noninfectious and are toxic to mammals only at high doses. Only two literature reports of Bt infection in man suggest an adverse effect of *Bt* infection and all infected individuals had experienced either extensive burns or a blast injury, which predisposed them to infection. Two epidemiology studies conducted during large-scale aerial *Bt* serovar *kurstaki* spray campaigns reported no increased incidence of illness. Laboratory studies found no evidence of illness in rats and sheep fed *Bt* products, nor have epidemiology studies found increased incidence of diarrhea during *Bt* aerial spray campaigns. Increases in human antibody levels following exposure to Bt products have been reported but there was no increased incidence in asthma or other illness. Based on laboratory studies and field experience, *Bt* insecticides have an excellent safety record.

Additional Bti Publications Reviewed

Publication Authors	Summary of Reported Findings
Stevens, M., S. Helliwell and P.A. Hughes. 2005. Toxicity of *Bacillus thuringiensis* var. *israelensis* Formulations, Spinosad and Selected Synthetic Insecticides to *Chironomus tepperi Larvae*. J. Amer. Mosq. Cont. Assoc. 21(4):446-450.	Three *Bacillus thuringiensis* var. *israelensis* (Bti) formulations, the bacterial metabolite spinosad, and 7 synthetic insecticides were bioassayed against 4th instars of *Chironomus tepperi*. LC_{50} values were adjusted to reflect nominal ITU values of the 3 products, but there was still substantial variation in the calculated toxicity (LC50 values ranging from 1,200 ITU/L (1gm) to 2,580 ITU/L (2.2 gm). The differential activity between formulations observed may be a beneficial characteristic when controlling benthic species such as *C. tepperi*. Spinosad and the synthetic insecticides evaluated were all substantially more active than Bti.
Stevens, M., R.J. Akhurst, M.A. Clifton, and P.A. Hughes. 2004. Factors Affecting the Toxicity of *Bacillus thuringiensis* var. *israelensis* and *Bacillus sphaericus* to Fourth Instar Larvae of *Chironomus tepperi* (Diptera: Chironomidae). J. Invert. Pathology 86(3):104-110.	Laboratory bioassays were used to determine the toxicity of commercial products of strains of *Bacillus thuringiensis* var. *israelensis*, VectoBac WDG, 3000ITU/mg (2.5 gm in 1 ml) and *Bacillus sphaericus* to fourth instar larvae of *Chironomus tepperi*. Bioassays were conducted using different temperatures and combinations of larval ages and densities to determine if these factors affected toxicity. Bti exposures of 20-46 mg/L was toxic to fourth instar *C. tepperi* in bioassays using a sand substrate, with age and density increasing LC50 values. The results suggest that the product VectoBac WDG has the potential to provide selective control of this rice pest at economically viable application rates. The proposed effective application rates are 1.78-2.48 lbs/acre. The maximum label rate for mosquito control is 0.89 lb/acre.
Tilquin, M. M. Paris, S. Reynaud, L. Despres, P. Ravanel, R.A. Geremia and J. Gury. 2008. Long Lasting Persistence of *Bacillus thuringiensis* subsp. *israelensis* in Mosquito Natural Habitats. PLoS ONE 3(10):1-10.	These studies address the issue of the persistence, potential proliferation and environmental accumulation of Bti in natural mosquito habitats. The authors contend that Bti environmental persistence may lengthen the exposure time of insects to Bti and could increase the risk of development of resistance and negative impact to nontarget insects. *The exposures used in these studies are unrealistic, irrelevant to actual purposeful applications of Bti*, based on the theory that if one exposes anything to anything long enough results (positive or negative) MAY occur. The authors contend that Bti (a soil microorganism) is already present in most areas so that applications should be considered additive and residual" toxicity" of Bti in the environment is problematic.
Vaughn, I., C. Newberry, D.J. Hall, J.S. Ligget and S.J. Omerod. 2008. Evaluating Large Scale Effects of *Bacillus thuringiensis* var. *israelensis* on Non-Biting Midges (Chironomidae) in a Eutrophic Urban Lake. Freshwater Biol. 53:2117-2128.	Bti effects on larval chironomids from eight experimental treatments, over 3 years, on a eutrophic, urban lake of 200 ha were assessed. Vectobac 12AS (liquid Bti) was applied at a rate of 6.07 liters/ acre which is 1.6 times the maximum label rate for midge control and 6.42 times the maximum label rate for mosquito control. The first two experimental years provided limited evidence of Bti effects, with chironomid densities reduced by up to 14%. Increased scale of application and altered experimental design in the third year revealed reductions in chironomid larval densities of around 35% following Bti treatment, with suppression lasting several months. Results suggest that near-neutral buoyancy formulations of Bti can reduce chironomid numbers in large lakes exceeding 3 m depth where treatment methods avoid over-dispersion. Further studies are recommended to evaluate whether chironomids can be suppressed over longer periods using whole-lake application without long-term ecological implications.
Waalwijk, C., A. Dullemans, G. Wiegers and P. Smits. 1992. Toxicity of *Bacillus thuringiensis* variety *israelensis* Against Tipulid Larvae. J. Appl. Ent. 114:415-420.	Tests with cultures of *Bacillus thuringiensis* were conducted for toxicity to both laboratory and field collected tipulid larvae (leatherjackets). Observed toxicity was shown to be primarily from the parasporal crystals. High pH in the midgut of the tipulid larva was required for the primary step in the pathogenesis of *B. thuringiensis* var. *israelensis*. The authors suggest that the toxicity of one of the Bti crystal proteins is a likely toxin to tipulid larvae. Additional bioassays suggested that *Escherichia coli* recombinants carrying this gene were toxic for L1 larvae of *Tipula oleracea*.

Additional Bti Publications Reviewed

Publication Authors	Summary of Reported Findings
Wirth, M. 2010. Mosquito Resistance to Bacterial Larvicidal Toxins. Open Toxicology Journal. 3:126-140.	Study of possible development of cross-resistance of *Bacillus thuringiensis*. *Bacillus sphaericus* (Bs) is at higher risk for resistance due to its single site action. Cross-resistance is reported among the various Bs isolates. Field and lab evolved resistant populations consistently show recessive and monofactorial inheritance of resistance. Recommended resistance management strategies include application rotations and using mixtures of Bti and Bs. The authors suggest that promising new strategies include genetic engineering to increase the toxin complexity targeted toward mosquito larvae, to enhance the host range of the mosquito control product, and to avoid the evolution of insecticide resistance.

Additional *B. sphaericus* Publications Reviewed

Publication Authors	Summary of Report Findings
Brown, M.D., T.M. Watson, J. Carter, D.M. Purdie and B.H. Kay. 2004. Toxicity of VectoLex (*Bacillus sphaericus*) Products to Selected Australian Mosquito and Nontarget Species. J. Econ. Ent. 97(1):51-58.	Laboratory and field bioassay (efficacy) studies were conducted in southeast Queensland, Australia, on the efficacy of VectoLex Control Granule (CG; active ingredient [AI]:50 *Bacillus sphaericus* [*Bs*] International Toxic Units [ITU]/mg, 50gm product/mg) and VectoLex Water Dispersible Granule (WDG) (AI: 650 *Bs* ITU/mg, 650 gm product/mg) formulations against third-instar larvae of *Culex annulirostris* Skuse, *Culex quinquefasciatus* Say, *Culex sitiens* Wiedemann, *Ochlerotatus rigilax* (Skuse), *Ochlerotatus*. *notoscriptus* (Skuse), and *Aedes aegypti* (L.). Laboratory 48-h LC95 values were determined. The *Bs* formulations were most effective against *Culex* spp., with the WDG 10-100 times more effective than the CG on an ITU/mosquito basis. Weekly cohorts of caged third-instar *Cx. annulirostris* were exposed to replicated low (250 g/ha), medium (500 g/ha), and high (1,000 g/ha) dosages of WDG. Concurrent assessment of *Cx. quinquefasciatus* mortality outside the cages was also conducted. In water with high organic content, the low rate produced > 99% *Cx. annulirostris* mortality at 48 h, decreasing to 79% at week 3 and no control at week 4. The medium and high rates resulted in 100% *Cx. annulirostris* mortality for 2 wk post treatment, decreasing to 95% at week 3, and no control at week 4. The WDG was equally effective against *Cx. quinquefasciatus*. *Treatment did not affect water quality or nontarget shrimp and fish species survival*.
Hurst, T.P., B.H. Kay, P.A. Ryan and M.D. Brown. 2007. Sublethal Effects of Mosquito Larvicides on Swimming Performance of Larvivorous Fish *Melanotaenia duboulayi* (Atheriniformes: Melantaeniidae). J. Econ. Ent. 100(1):61-65.	Laboratory studies were conducted to determine the sublethal effects of exposure to the mosquito larvicides temephos, primiphos-methyl, Bti, Bacillus sphaericus, and methoprene. *Bacillus sphaericus* exposures of 10 times the effective field concentration had no effect on the Australian Crimson-Spotted Rainbowfish (*Melanotaenia duboulayi*) swimming speed.
Merritt, R.W., J.L. Lessard, K.J. Wessell, O. Hernandez, M.B. Berg, J.R. Wallace, J.A. Novak, J. Ryan and B.W. Merritt. 2005. Lack of Effects of *Bacillus sphaericus* (VectoLex) on Nontarget Organisms in a Mosquito-Control Program in Southeastern Wisconsin: A 3 Year Study. J. Amer. Mosq. Cont. Assoc. 21(2):201-212.	A 3-year study (2000-2002) in southeastern Wisconsin was conducted to assess the effects of *Bacillus sphaericus* applied for mosquito control on nontarget wetland invertebrates. The experimental design consisted of control and treatment sites (that were applied by helicopter with VectoLex CG), each in 2 vegetation habitat types: reed canary grass marsh (*Phalaris arundinacea*) and cattail marsh (*Typha* spp.). In each of these areas, a predetermined number of timed (30-sec) D-frame aquatic net samples containing vegetation, detritus, and invertebrates were collected 1 day before spraying and 72 h after spraying to detect for effects. We examined and compared 5 bioassessment measures to determine if there was an effect of *B. sphaericus* on nontarget organisms during each of the sampling years. The metrics tested were (1) mean taxa richness (the mean number of all taxa), (2) mean diversity (combines taxa richness and abundances in a summary statistic; i.e., Shannon Index [H'I]), (3) Diptera richness (minus mosquitoes) as a proportion of all other taxa richness (Diptera/others richness), (4) Diptera abundance (minus mosquitoes) as a proportion of all other invertebrate abundance (Diptera/others abundance), and (5) functional group changes in percent collector-gatherers, collector-filterers, scrapers, shredders, and predators. When VectoLex was applied during *6 treatments at the labeled dosage*, no detrimental effects to nontarget organisms could be attributed to this microbial insecticide. Variation in the control vs. treatment and pre vs. post plots was attributed to factors other than the effects of *B. sphaericus* on nontarget organisms, (time of sampling, natural variation that occurs in such diverse habitats as canary grass and cattail marshes, and water depth, which varied among years).

Additional *B. sphaericus* Publications Reviewed

Publication Authors	Summary of Report Findings
Negri, A.P., R.M. Soo, F. Flores and N.S. Webster. 2009. Bacillus Insecticides are not Acutely Harmful to Corals and Sponges. Mar. Ecol. Prog. Ser. 381:157-165.	Bacteria closely related to *B. thuringiensis* have recently been discovered in association with diseased sponges, which has raised concerns that *Bacillus* insecticides may be harmful to tropical marine invertebrates. Coral larvae and juvenile corals were exposed to the insecticides VectoBac® G (containing *B. thuringiensis israelensis*) and VectoLex® G (containing *B. sphaericus*) at concentrations up to 100 fold higher than concentrations that affect immature mosquitoes. VectoBac G and VectoLex G had no effect on the survival and metamorphosis of *Acropora millepora* and *A. tenuis* larvae *at very high concentrations (5000 µg l^{-1}*). The juvenile corals of the same species were also unaffected after 4 sequential 48 h exposures to *B. thuringiensis israelensis* and *B. sphaericus* at different stages of development. These results indicate that insecticides containing *Bacillus* spp. are unlikely to be acutely pathogenic to corals and sponges.
Poopathi, S. and S. Abidha. 2010. Mosquitocidal Bacterial Toxins (*Bacillus sphaericus* and *Bacillus thuringiensis* serovar *israelensis*): Mode of Action, Cytopathological Effects and Mechanism of Resistance. J. Physiol. Pathophysiol. 1(3):22-38.	This paper provides a general overview and test data discussing the use of Bs and Bti (*Bacillus sphaericus* and *Bacillus thuringiensis* serovar *israelensis*) to provide effective alternatives to broad spectrum larvicides in many situations with little or no environmental impact. New recombinant bacteria are as potent as many synthetic chemical insecticides yet are less prone to resistance, as they typically contain a mixture of endotoxins with different modes of action.
Stevens, M.M., et al., 2004. Factors Affecting the Toxicity of *Bacillus thuringienss* var. *israelensis* and *Bacillus sphaericus* to Fourth Instar Larvae of *Chironomus tepperi* (Diptera: Chironomidae). J. Invert. Pathology. 86(3):104-110.	Laboratory bioassays were used to determine the toxicity of commercial products of strains of *Bacillus thuringiensis* var. *israelensis* Vectobac WDG, 3000 ITU/mg (2.5 gm in 1 ml) and *Bacillus sphaericus*, VectoLex WDG, 650 ITU/mg, to fourth instar larvae of *Chironomus tepperi*. Bioassays were conducted using different temperatures and combinations of larval ages and densities to determine if these factors affected toxicity. VectoLex WDG showed very low toxicity to *C. tepperi* larvae, and the overall impact of larval age and density was relatively minor (LC50 values 1062-1340 mg/L). VectoLex WDG was determined to be ineffective against the Australian rice pest *C. tepperi*.

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Integrated Vector
Management Program

APPENDIX

C

AIR QUALITY AND GHG TECHNICAL REPORT

Air Quality and Greenhouse Gases Technical Report

Project Name: Integrated Mosquito and Vector Management Programs for Nine Districts

Date: June 2013

Prepared for:

Alameda County Mosquito Abatement District
Alameda County Vector Control Services District
Contra Costa Mosquito and Vector Control District
Marin/Sonoma Mosquito Vector Control District
Napa County Mosquito Abatement District
Northern Salinas Valley Mosquito Abatement District
San Mateo County Mosquito and Vector Control District
Santa Clara County Vector Control District
Solano County Mosquito Abatement District

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Acronyms

°C	degrees Celsius
°F	degrees Fahrenheit
AB	Assembly Bill
ACMAD	Alameda County Mosquito Abatement District
ACVCSD	Alameda County Vector Control Services District
ATCM	Airborne Toxic Control Measure
BAAQMD	Bay Area Air Quality Management District
CAA	Clean Air Act of 1970
CAAQS	California Ambient Air Quality Standards
CARB	California Air Resources Board
CCMVCD	Contra Costa Mosquito and Vector Control District
CCR	California Code of Regulations
CDFA	California Department of Food and Agriculture
CDFG	California Department of Fish and Game
CDPH	California Department of Public Health
CDPR	California Department of Pesticide Regulation
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
DPM	Diesel particulate matter
GHG	greenhouse gas
GWP	Global Warming Potential
IPCC	Intergovernmental Panel on Climate Change
MBUAPCD	Monterey Bay Unified Air Pollution Control District
MEI	Maximally Exposed Individual
MSMVCD	Marin/Sonoma Mosquito Vector Control District
MVC	mosquito and vector control
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NCMAD	Napa County Mosquito Abatement District
NMFS	National Marine Fisheries Service

NO	nitric oxide
NO_2	nitrogen dioxide
NO_X	nitrogen oxides
NSCAPCD	Northern Sonoma County Air Pollution Control District
NSVMAD	Northern Salinas Valley Mosquito Abatement District
O_3	ozone
PERP	Portable Equipment Registration Program
PM_{10}	respirable particulate matter
$PM_{2.5}$	fine particulate matter
ppm	part(s) per million
ROCs	reactive organic compounds
ROGs	reactive organic gases
RWQCB	Regional Water Quality Control Board
SB	Senate Bill
SCAQMD	South Coast Air Quality Management District
SCCVCD	Santa Clara County Vector Control District
SCMAD	Solano County Mosquito and Vector Control District
SFBAAB	San Francisco Bay Area Air Basin
SJVAPCD	San Joaquin Valley Air Pollution Control District
SMCMVCD	San Mateo County Mosquito and Vector Control District
SO_2	sulfur dioxide
SWRCB	State Water Resources Control Board
UNFCCC	United Nations Framework Convention on Climate Change
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VOCs	volatile organic compounds
YSAQMD	Yolo-Solano Air Quality Management District

1 Introduction

This report provides a description of the air quality and climate change environmental setting for and impacts of the Integrated Mosquito and Vector Management Programs (Programs) for nine mosquito abatement and/or vector control districts in northern California. The nine districts are: Alameda County Mosquito Abatement District (ACMAD), Alameda County Vector Control Services District (ACVCSD), Contra Costa Mosquito and Vector Control District (CCMVCD), Marin/Sonoma Mosquito Vector Control District (MSMVCD), Napa County Mosquito Abatement District (NCMAD), Northern Salinas Valley Mosquito Abatement District (NSVMAD), San Mateo County Mosquito and Vector Control District (SMCMVCD), Santa Clara County Vector Control District (SCCVCD), and the Solano County Mosquito Abatement District (SCMAD).The Programs provide for mosquito and/or vector control activities within each District's Program Area. The nine District Program Areas include both the areas within the Districts (their individual Service Areas) and the surrounding counties where the Districts may provide mosquito and/or other vector management services when requested.

The immediate nine District Service Areas are located in the following nine counties of the state: Alameda, Contra Costa, Marin, Monterey, Napa, San Mateo, Santa Clara, Solano, and Sonoma. Control activities may also be provided in areas adjacent to the District Service Areas upon request of the adjacent jurisdictions to protect the health and safety of residents in adjacent jurisdictions. Actions that would be taken outside of the nine Districts' Service Areas are the same types of actions undertaken within the Districts' Service Areas and in similar types of habitats or sites. Therefore, the nine District Program Areas addressed in this report also include the ten surrounding counties: Mendocino, Merced, Lake, Sacramento, San Benito, San Francisco, San Joaquin, Santa Cruz, Stanislaus, Yolo, and the portion of Monterey County south of the NSVMAD.

The bulk of criteria pollutant and greenhouse gas emissions resulting from Program activities would occur in the San Francisco Bay Area, and minor amounts would occur in northern Sonoma, Yolo, Solano, and northern Monterey counties. The following chapters characterize and quantify Program emissions on a year-round basis. Chapter 2 addresses air quality, and Chapter 3 covers greenhouse gases.

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2 Air Quality

2.1 Introduction

State and Federal law defines criteria emissions to include the following: reactive or volatile organic compounds (ROCs or VOCs), nitrogen oxides (NO and NO_2), carbon monoxide (CO), sulfur dioxide (SO_2), respirable particulate matter (PM_{10}), and fine particulate matter ($PM_{2.5}$). Elimination of tetraethyl lead in motor gasoline has eliminated emissions of lead (Pb) from vehicles and portable equipment, although tetraethyl lead is still used in some types of aviation gasoline.

During applicable mosquito and/or vector control activities, the Programs would cause criteria emissions from the combustion of fossil fuels (i.e., gasoline, diesel, jet fuel) used to operate portable equipment, vehicles, and aircraft primarily across the nine-county region comprising the MVCAC Nine Districts' Service Areas. Control activities would also cause emissions of greenhouse gases, which is addressed in the next chapter. This report evaluates Program emissions to determine individual and combined effects in relation to established thresholds of significance.

2.2 Environmental Setting

The Service Areas comprise Alameda, Contra Costa, Marin, Sonoma, Napa, Solano, San Mateo, and Santa Clara counties, and the northern portion of Monterey County. These counties are predominantly in the San Francisco Bay Area Air Basin (SFBAAB), under the jurisdiction of the Bay Area Air Quality Management District (BAAQMD), along with the Northern Sonoma County Air Pollution Control District (NSCAPCD), the Yolo-Solano Air Quality Management District (YSAQMD), and the Monterey Bay Unified Air Pollution Control District (MBUAPCD) in adjacent areas.

Air districts in California are required to monitor air pollutant levels to assure that National Ambient Air Quality Standards (NAAQS) and California Ambient Air Quality Standards (CAAQS) are met and, in the event that they are not, to develop strategies to meet these standards. If the standards are met, the local air basin is classified as being in "attainment"; if the standards are exceeded, it is classified as "nonattainment." Where insufficient data exist to make a determination, an area is deemed "unclassified."

The SFBAAB is designated as nonattainment for the state 1-hour, state 8-hour, and Federal 8-hour ozone ($O_{3)}$ standards, and nonattainment for all state PM_{10} and $PM_{2.5}$ (i.e., respirable particulate matter with an aerodynamic diameter of 10 and 2.5 micrometers or less) standards. The SFBAAB is also designated unclassified for the 24-hour Federal PM_{10} standard, and nonattainment and attainment for the Federal 24-hour and annual $PM_{2.5}$ standards, respectively. For all other pollutants and standards, the SFBAAB is designated as either attainment or unclassified status (BAAQMD 2012a, CARB 2012b, EPA 2012a, see Table 2-2 below).

Northern Sonoma County is designated transitional/uncharacterized for the state 1-hour ozone standard. Monterey County is "Moderate" nonattainment for state 1-hour ozone standard and nonattainment for the state PM_{10} standard. Yolo and Solano counties are "Serious" nonattainment for the state 1-hour O_3 standard, nonattainment for the state and federal 8-hour O_3 standards, nonattainment for the state 24-hour and annual PM_{10} standards, and partial nonattainment for the Federal 24-hour $PM_{2.5}$ standard. For all other pollutants and standards northern Sonoma, Yolo, Solano, and Monterey counties are designated either attainment or unclassified status. (CARB 2012b, EPA 2012a, YSAQMD 2013)

2.2.1 Meteorology and Climate

The Program Area climate is characterized by moderately wet winters and dry summers. About 90 percent of the annual total rainfall is received in the November through April period. Between June and

September, normal rainfall is typically less than 0.6 inch (1.5 centimeters). Temperatures in the Program Area average about 60°F (15°C) annually, with average summer highs in the 70 to 80°F (21 to 27°C) range and average winter lows in the 40 to 50°F (4 to 10°C) range. Precipitation averages about 23 inches (58 centimeters) per year, although annual precipitation can vary significantly from year-to-year. Annual average wind speeds in the Program Area are about 8 miles per hour (3.6 meters per second). The predominant direction of air pollution transport in the Program Area is inland from the coastal areas (BAAQMD 2010a, WC 2012, NOAA 2008).

2.2.2 Criteria Air Pollutants

A criteria or regulated air pollutant is any air pollutant for which ambient air quality standards have been set by the U.S. Environmental Protection Agency (EPA) or the California Air Resources Board (CARB). Primary air quality standards are established to protect human (public) health. Secondary air quality standards are designed to protect public welfare from effects such as diminished production and quality of agricultural crops, reduced visibility, degraded soils, materials and infrastructure damage, and damaged vegetation. Criteria pollutants include O_3, NO_2, CO, SO_2, PM_{10}, and $PM_{2.5}$. The six most prevalent criteria pollutants and their potential health effects are described below.

Ozone

Ground-level O_3 is a secondary pollutant formed in the atmosphere by a series of complex chemical reactions and transformations in the presence of sunlight above urban areas due to the mixing effects of temperature inversions. Nitrogen oxides (NO_X) and reactive organic gases (ROGs)[1] are the principal constituents in these reactions. NO_X and ROG emissions are predominantly attributed to mobile sources (on-road motor vehicles and other mobile sources). Thus, regulation and control of NO_X and ROGs from these sources is essential to reduce the formation of ground-level O_3.

O_3 is a strong irritating gas that can chemically burn and cause narrowing of airways, forcing the lungs and heart to work harder to provide oxygen to the body. A powerful oxidant, O_3 is capable of destroying organic matter, including human lung and airway tissue; it essentially burns through cell walls. O_3 damages cells in the lungs, making the passages inflamed and swollen. O_3 also causes shortness of breath, nasal congestion, coughing, eye irritation, sore throat, headache, chest discomfort, breathing pain, throat dryness, wheezing, fatigue, and nausea. It can damage alveoli, the individual air sacs in the lungs where oxygen and carbon dioxide are exchanged. O_3 has been associated with a decrease in resistance to infections. People most likely to be affected by O_3 include the elderly, the young, and athletes. O_3 may pose its worst health threat to people who already suffer from respiratory diseases such as asthma, emphysema, and chronic bronchitis (VCAPCD 2003).

Nitrogen Dioxide

NO_2 is formed in the atmosphere primarily by the rapid reaction of the colorless gas nitric oxide (NO) with atmospheric oxygen. It is a reddish brown gas with an odor similar to that of bleach. NO_2 participates in the photochemical reactions that result in O_3. The greatest source of NO, and subsequently NO_2, is the high-temperature combustion of fossil fuels such as in motor vehicle engines and power plant boilers. NO_2 and NO are referred to collectively as NO_X. NO_2 can irritate and damage the lungs, cause bronchitis and pneumonia, and lower resistance to respiratory infections such as influenza. Researchers have identified harmful effects, similar to those caused by O_3, with progressive changes over four hours of exposure causing impaired pulmonary function, increased incidence of acute respiratory disease, and difficult breathing for both bronchitis sufferers and healthy persons (VCAPCD 2003).

[1] Also referred to as reactive organic compounds (ROCs) or volatile organic compounds (VOCs).

Carbon Monoxide

CO is a common, colorless, odorless, highly toxic gas. It is produced by natural and anthropogenic (caused by human activity) combustion processes. The major source of CO in urban areas is incomplete combustion of carbon-containing fuels (primarily gasoline, diesel fuel, and natural gas). However, it also results from combustion processes including forest fires and agricultural burning. Ambient CO concentrations are generally higher in the winter, usually on cold, clear days and nights with little or no wind. Low wind speeds inhibit horizontal dispersion, and surface inversions inhibit vertical mixing. Traffic-congested intersections have the potential to result in localized high CO levels.

When inhaled, CO does not directly harm the lungs. The impact from CO is on oxygenation of the entire body. CO combines chemically with hemoglobin, the oxygen-transporting component of blood. This diminishes the ability of blood to carry oxygen to the brain, heart, and other vital organs. Red blood cells have 220 times the attraction for CO as for oxygen. This affinity interferes with movement of oxygen to the body's tissues. Effects from CO exposure include headaches, nausea, and death. People with heart ailments are at risk from low-level exposure to CO. Also sensitive are people with chronic respiratory disease, the elderly, infants and fetuses, and people suffering from anemia and other conditions that affect the oxygen-carrying capacity of blood. High CO levels in a concentrated area can result in asphyxiation. Studies show a synergistic effect when CO and O_3 are combined (VCAPCD 2003).

Sulfur Dioxide

SO_2 is a colorless gas with a sharp, irritating odor. It can react in the atmosphere to produce sulfuric acid and sulfates, which contribute to acid deposition and atmospheric visibility reduction. It also contributes to the formation of PM_{10}. Most of the SO_2 emitted into the atmosphere is from burning sulfur-containing fossil fuels by mobile sources such as marine vessels and farm equipment and stationary fuel combustion. SO_2 irritates the mucous membranes of the eyes and nose and may also affect the mouth, trachea, and lungs. Healthy people may experience sore throats, coughing, and breathing difficulties when exposed to high concentrations. SO_2 causes constriction of the airways and poses a health hazard to asthmatics, which are very sensitive to SO_2. Children often experience more respiratory tract infections when they are exposed to SO_2 (VCAPCD 2003).

Respirable Particulate Matter, 10 Microns

PM_{10} consists of particulate matter, fine dusts and aerosols, 10 microns or smaller in diameter. When inhaled, particles larger than 10 microns generally are caught in the nose and throat and do not enter the lungs. PM_{10} can enter the large upper branches of the lungs just below the throat, where they are caught and removed (by coughing, spitting, or swallowing).

The primary sources of PM_{10} include dust from paved and unpaved roads and construction and demolition operations. Lesser sources of PM_{10} include wind erosion, agricultural operations, residential wood combustion, smoke, tailpipe emissions, and industrial sources. These sources have different constituents, and, therefore, varying effects on health. Road dust is composed of many particles other than soil dust. It also includes engine exhaust, tire rubber, oil, and truck load spills. Diesel particulate matter (DPM) contains many toxic particle and elemental carbon (soot), and is considered a toxic air contaminant in California. Airborne particles absorb and adsorb toxic substances and can be inhaled and lodge in the lungs. Once in the lungs, the toxic substances can be absorbed into the bloodstream and carried throughout the body. PM_{10} concentrations tend to be lower during the winter months because weather greatly affects PM_{10} concentrations. During rain, concentrations are relatively low, and on windy days, PM_{10} levels can be high. Photochemical aerosols, formed by chemical reactions with manmade emissions, may also influence PM_{10} concentrations.

Elevated ambient particulate levels are associated with premature death, an increased number of asthma attacks, reduced lung function, aggravation of bronchitis, respiratory disease, cancer, and other serious health effects. Short-term exposure to particulates can lead to coughing, minor throat irritation, and a

reduction in lung function. Long-term exposure can be more harmful. EPA estimates that 8 percent of urban nonsmoker-lung-cancer-risk is due to PM_{10} in soot from diesel trucks, buses, and cars. Additional studies by EPA and the Harvard School of Public Health estimate that 50,000 to 60,000 deaths per year in the United States are caused by particulates. PM_{10} particles collect in the upper portion of the respiratory system, affecting the bronchial tubes, nose, and throat. They contribute to aggravation of asthma, premature death, increased number of asthma attacks, bronchitis, reduced lung function, respiratory disease, aggravation of respiratory and cardiovascular disease, alteration of lung tissue and structure, changes in respiratory defense mechanisms, and cancer (VCAPCD 2003).

Fine Particulate Matter, 2.5 Microns

$PM_{2.5}$ is a mixture of particulate matter fine dusts and aerosols 2.5 microns or smaller in aerodynamic diameter. $PM_{2.5}$ can enter the deepest portions of the lungs where gas exchange occurs between the air and the blood stream. These are the most dangerous particles because the lungs have no efficient mechanisms for removing them. If these particles are soluble in water, they pass directly into the blood stream within minutes. If they are not soluble in water, they are retained deep in the lungs and can remain there permanently. This increases the risks of long-term disease including chronic respiratory disease, cancer, and increased and premature death. Other effects include increased respiratory stress and disease, decreased lung function, alterations in lung tissue and structure, and alterations in respiratory tract defense mechanisms.

$PM_{2.5}$ particles are emitted from activities such as industrial and residential combustion processes, wood burning, and from diesel and gasoline-powered vehicles. They are also formed in the atmosphere from gases such as SO_2, NO_X, ammonia, and VOCs that are emitted from combustion activities and then become particles as a result of chemical transformations in the air (secondary particles) (VCAPCD 2003).

2.2.3 Sources of Air Pollutants

The most significant regional sources of O_3, NO_2, and CO in ambient air are automobiles, trucks, and other on-road vehicles, along with trains, vessels, and aircraft. O_3 is not directly emitted; rather, photochemical O_3 is formed by the atmospheric reaction of VOCs and NO_X in sunlight. Gasoline and diesel engines emit VOCs and NO_X as combustion products, as does natural gas fired equipment (stationary sources) such as pump engines, gas turbine generators, process heaters, and steam boilers.

Local emissions of PM_{10} are primarily the result of fugitive dust from travel on unpaved roads, as well as construction and agricultural activities. Coarser particles also may be emitted from activities that disturb the topsoil. Other sources include wind-blown dust, pollen, salts, brake dust, and tire wear. Although $PM_{2.5}$ is a subset of PM_{10}, it differs from the rest of PM_{10}. While most of the ambient PM_{10} results from direct emissions of the pollutant, a significant amount of the ambient $PM_{2.5}$ results from transformation of precursors and condensing of gaseous pollutants in the atmosphere. Other than direct $PM_{2.5}$ emissions, the key pollutants contributing to $PM_{2.5}$ concentrations in the atmosphere are SO_2, NO_X, VOCs, and ammonia (CARB 2005).

Mobile sources used in mosquito and vector control (MVC) activities include onroad fleet vehicles (light- and medium-duty trucks, vans, passenger cars), offroad all-terrain vehicles (ATVs), watercraft (motorboats, airboats), aircraft (helicopters and fixed-wing), portable equipment (pumps, sprayers, generators), and small equipment (hand-held sprayers, foggers, dusters). Except for 2-stroke engines used in small lightweight equipment (spark ignition, 50:1 gas/oil mix), engines are 4-stroke gasoline (spark ignition) or diesel fuel (compression ignition). The dominant fuel used for these mobile sources is motor gasoline along with some diesel fuel (larger trucks) , aviation gasoline (fixed-wing aircraft), and jet fuel (turbine-powered helicopters). Light trucks, vans, and passenger cars are normally used for responding to public service requests and disease surveillance.

2.2.4 Ambient Air Quality

Air quality is affected by a variety of sources in the vicinity of the Program Areas. Large stationary sources such as oil refineries and power plants emit substantial amounts of NO_X and ROCs, along with PM_{10} and $PM_{2.5}$. Light motor vehicles, diesel powered construction equipment, and commercial trucks used in the Program Area are another source of these pollutants. Noncombustion sources of PM_{10} and $PM_{2.5}$ include fugitive dust from roads, construction, demolition, and earthmoving. Finally, commercial and general aviation aircraft generate emissions that affect air quality.

O_3 is a secondary pollutant that is not emitted directly by sources, but rather is formed by a reaction between NO_X and ROCs in the presence of sunlight. Reductions in O_3 concentrations are dependent upon reducing emissions of these precursors. The major sources of O_3 precursors in the Bay Area are motor vehicles and other mobile equipment (including agricultural equipment), solvent use, petroleum industry activities, nonelectric agricultural water pumping, and electric utilities operation.

BAAQMD, NSCAPCD, and SJVAPCD operate extensive regional air monitoring networks comprised of monitoring stations (sites) that collectively measure the ambient concentrations of six criteria air pollutants: ozone (O_3), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), respirable particulates (PM_{10}), and fine particulates ($PM_{2.5}$). Not all monitoring stations are fully instrumented for these pollutants, while some sites have not been operating for adequate periods of time to provide representative data for characterization of attainment status.

2.2.5 Sensitive Receptors

Certain population groups are considered more sensitive to air pollution and odors than others; in particular, children, elderly, and acutely ill and chronically ill persons, especially those with cardio respiratory diseases such as asthma and bronchitis. Sensitive receptors (land uses) indicate locations where such individuals are typically found, namely schools, daycare centers, hospitals, convalescent homes, residences of sensitive persons, and parks with active recreational uses, such as youth sports.

Persons engaged in strenuous work or physical exercise also have increased sensitivity to poor air quality. Residential areas are considered more sensitive to air quality conditions than commercial and industrial areas, because people generally spend longer periods of time at their residences, resulting in greater exposure to ambient air quality conditions. Recreational uses such as parks are also considered sensitive, due to the greater exposure to ambient air quality conditions and because the presence of pollution detracts from the recreational experience.

Due to the very wide geographic dispersion of the nine MVCAC Districts' activities and their short-term temporary nature at any particular location, no quantifiable risk to sensitive receptors or the general public would be posed by Program-related engine exhaust.

2.3 Regulatory Setting

The following paragraphs describe the Federal, state, and local agencies and the laws and regulations governing air quality. *It is the practice of the nine MVCAC Districts to work with Service Area jurisdictions and agencies during Program planning to reasonably consider the local environmental protection policies and to conform to the extent required.*

2.3.1 Standards and Attainment Status

The Clean Air Act of 1970 (CAA, amended 1977 and 1990, 42 United States Code 7401 et seq.) established NAAQS, and individual states retained the option to adopt more stringent standards and to include other pollution sources. California had already established its own air quality standards when Federal standards were established, and because of the unique meteorological problems in the state, there is considerable diversity between the Federal and the state standards currently in effect in

California, as shown in Table 2-1 below. CAAQS tend to be at least as protective as national standards and are often more stringent.

Table 2-1 Ambient Air Quality Standards

Pollutant	Averaging Time	California Standards		Federal Standards	
		ppmv	µg/m^3	ppmv	µg/m^3
Ozone (O_3)	1-hour	0.09	177	—	—
	8-hour	0.07	137	0.075	147
Nitrogen Dioxide (NO_2)	1-hour	0.18	338	0.100	188
	Annual	0.03	56	0.053	100
Sulfur Dioxide (SO_2)	1-hour	0.25	655	0.075	196
	3-hour Secondary	—	—	0.50	1,309
	24-hour	0.04	105	—	—
Carbon Monoxide (CO)	1-hour	20	22,898	35	40,071
	8-hour	9	10,304	9	10,304
	Lake Tahoe (8-hr)	6	6,869	—	—
Particulates (as PM_{10})	24-hour	—	50	—	150
	Annual	—	20	—	—
Particulates (as $PM_{2.5}$)	24-hour	—	—	—	35
	Annual Primary	—	12	—	12
	Annual Secondary	—	—	—	15
Lead (Pb)	30-day	—	1.5	—	—
	3-month (rolling)	—	—	—	0.15
Sulfates (as SO_4)	24-hour	—	25	—	—
Hydrogen Sulfide (H_2S)	1-hour	0.03	42	—	—
Vinyl Chloride (C_2H_3Cl)	24-hour	0.01	26	—	—
Visibility Reducing Particles	8-hour	Extinction coefficient of 0.23 per km; visibility of 10 miles or more (0.07 to 30 miles or more for Lake Tahoe) due to particles when relative humidity is less than 70%.		—	—

Sources: CARB 2012a, EPA 2011a

Notes:

ppmv = parts per million by volume

µg/m^3 = micrograms per cubic meter

The 1.5 µg/m^3 Federal quarterly lead standard applied until 2008; 0.15 µg/m^3 rolling 3-month average thereafter

For gases, µg /m^3 calculated from ppmv based on molecular weight and standard conditions

Standard Temperature 25°C

Standard Molar Volume 24.465 liter/g-mole

The ambient air quality standards shown in Table 2-1 are intended to protect the public health and welfare and specify the concentration of pollutants (with an adequate margin of safety) to which the public may be exposed without adverse health effects. The standards are designed to protect those segments of the public most susceptible to respiratory distress (known as sensitive receptors), including asthmatics, the very young, the elderly, people weak from other illness or disease, or persons engaged in strenuous work or exercise. Healthy adults can tolerate occasional exposure to air pollution levels somewhat above the ambient air quality standards before adverse health effects are observed.

As previously described, air districts in California are required to monitor air pollutant levels to assure that NAAQS and CAAQS are met and, in the event that they are not, to develop strategies to meet these standards. Depending on whether the standards are met or exceeded, the local air basin is classified as being in "attainment" or "nonattainment." Where insufficient data exist to make a determination, an area is deemed "unclassified."

In general, the San Francisco Bay Area experiences low concentrations of most pollutants when compared to state and Federal standards, except for O_3 and particulate matter, for which standards are exceeded periodically. Portions of Sonoma and Monterey counties also experience mildly elevated concentrations of ozone, resulting in state-level transitional and moderate nonattainment designations, respectively. Monterey County is also nonattainment for the state PM_{10} standard (MBUAPCD 2009, CARB 2012b). The attainment status of the main Bay Area region is shown in Table 2-2.

Table 2-2 Attainment Status Summary - Bay Area Region

Criteria Pollutant	State Designation	Federal Designation
Ozone (O_3) (1-hour)	Nonattainment	—
Ozone (O_3) (8-hour)	Nonattainment	Nonattainment[(1)]
Nitrogen Dioxide (NO_2) (1-hour)	Attainment	Unclassified[(2)]
Nitrogen Dioxide (NO_2) (annual)	Attainment	Attainment
Sulfur Dioxide (SO_2)	Attainment	Attainment
Carbon Monoxide (CO)	Attainment	Attainment
Resp. Particulates (as PM_{10}) (24-hour)	Nonattainment	Unclassified[(2)]
Resp. Particulates (as PM_{10}) (annual)	Nonattainment	—
Fine Particulates (as $PM_{2.5}$) (24-hour)	—	Nonattainment
Fine Particulates (as $PM_{2.5}$) (annual)	Nonattainment	Attainment
Lead (Pb)	Attainment	Attainment
Sulfates (as SO_4)	Attainment	—
Hydrogen Sulfide (H_2S)	Unclassified[(2)]	—
Vinyl Chloride (C_2H_3Cl)	n/d	—
Visibility	Unclassified[(2)]	—

Source: BAAQMD 2012a

Notes:

(1) The 0.08 ppmv Federal 8-hour ozone standard applied until 2008; 0.075 ppmv thereafter

(2) At the time of designation, if the available data does not support a designation of attainment or nonattainment, the area is designated as unclassified.

n/d = no data/information available

2.3.2 Federal Authority

The 1977 CAA amendments required that regional planning and air pollution control agencies prepare regional air quality plans to outline the measures by which both stationary and mobile sources of pollutants can be controlled to achieve all standards by the deadlines specified in the act.

For the SFBAAB, the Association of Bay Area Governments, the Metropolitan Transportation Commission, and BAAQMD jointly prepared the *2005 Bay Area Ozone Strategy,* which provided inputs to the most recent *2010 Clean Air Plan* issued by BAAQMD (2012a). These plans contain control strategies that demonstrate attainment with NAAQS by the deadlines established in the Federal CAA and become part of the State Implementation Plan (SIP) administered by CARB and submitted to EPA. Similarly, NSCAPCD and MBUAPCD are also required to prepare and submit tailored clean air implementation plans to state and Federal regulators.

Under the 1990 CAA amendments, areas that did not meet the original Federal 1-hour O_3 standard were classified according to the severity of each area's respective O_3 problem. The 1-hour classifications were Marginal, Moderate, Serious, Severe, and Extreme. Marginal areas were closest to meeting the 1-hour O_3 standard. Extreme areas had the worst air quality problems. Areas with severe O_3 problems had progressively more stringent control requirements to meet under the Act. An area's classification determined how long the area had to attain the O_3 standard. Marginal areas had 3 years; Moderate areas had 6 years; Serious areas had 9 years; Severe areas had either 15 or 17 years, depending on the magnitude of their O_3 problem; and Extreme areas had 20 years. Under the Act, the Bay Area Air Basin is a "Serious" Federal nonattainment area for O_3 and a Federal nonattainment area for $PM_{2.5}$.

2.3.3 State Authority

Pursuant to the Federal CAA, states have the right to establish and enforce their own air quality standards; state standards may be equal to or more stringent, but not less stringent than Federal standards. In 1988, the state legislature passed the California CAA (California Health and Safety Code Section 39600 et seq.), which, like its Federal counterpart, called for designations of areas as attainment or nonattainment based on state rather than Federal standards.

Similar to the Federal CAA, the California CAA also classifies areas according to pollution levels. Under the Act, the Bay Area is a "Serious" O_3 nonattainment area and state PM_{10} and $PM_{2.5}$ nonattainment areas. In addition, localized CO concentrations, also known as CO "hotspots," may occur at heavily traveled roadways, particularly at intersections or other locations where the traffic is congested and vehicles idle for prolonged periods. CO concentrations exceeding the existing standard may occur at intersections that operate at a Level of Service D or worse.

CARB is the state agency responsible for regulating air quality, and its responsibilities include establishing state ambient air quality standards, emissions standards, and regulations for mobile emissions sources (e.g., autos, trucks, etc.) as well as overseeing the efforts of countywide and multicounty air pollution control districts, which have primary responsibility over stationary sources. The emission standards most relevant to the Programs are those related to automobiles, light- and medium-duty trucks, and California heavy-duty truck and construction equipment engines. CARB also regulates vehicle fuels with the intent to reduce emissions; to this end, the CARB has set emission reduction performance requirements for gasoline (California reformulated gasoline) and has stringently limited the sulfur and aromatic content of diesel fuel to make it burn cleaner. CARB also sets the standards used to pass or fail vehicles in smog check and heavy-duty truck inspection programs.

2.3.4 Local Authority

BAAQMD is the regional agency responsible for air quality regulation within the San Francisco Bay Area, along with NSCAPCD and MBUAPCD in their respective jurisdictions. These districts regulate air quality through planning, monitoring, rulemaking, permitting, and enforcement activities. Districts have permit

authority over most types of stationary emission sources and can require stationary sources to obtain permits; they can also impose emission limits, set fuel or material specifications, or establish operational limits to reduce air emissions. BAAQMD also regulates new or expanding stationary sources of toxic air contaminants. For state air quality planning purposes, the Bay Area is classified by the California CAA as a nonattainment area for O_3. The "Serious" classification triggers various plan submittal requirements and transportation performance standards. One such requirement is that each district update its air quality attainment plan every three years (triennially) to reflect progress in meeting the air quality standards and to incorporate new information regarding the feasibility of control measures and new emission inventory data. Districts indirectly regulate construction projects that use mobile sources via the statewide Portable Equipment Registration Program discussed below. Since the Programs do not meet the definition of permanent stationary sources, no permits would be required from the BAAQMD, NSCAPCD, or MBUAPCD.

2.4 Source-Specific Regulations

Non-road Engine Standards

CARB regulates mobile sources of air pollution in the State of California. Self-propelled nonroad construction equipment is considered a vehicle, as defined by the California Vehicle Code. A vehicle may have an engine that both propels the vehicle and powers equipment mounted on the vehicle. As such, vehicles are generally exempt from regulation by the air districts. However, not included in exemption provisions is any equipment mounted on a vehicle that would otherwise require a permit under air district rules and regulations.

Federal Tier 1 standards for off-road diesel engines were adopted as part of the California requirements for 1995. Federal Tier 2 and Tier 3 standards were adopted in 2000 and selectively apply to the full range of diesel off-road engine power categories. Both Tier 2 and Tier 3 standards include durability requirements to ensure compliance with the standards throughout the useful life of the engine (40 Code of Federal Regulations [CFR] 89.112, 13 California Code of Regulations [CCR] 2423).

On May 11, 2004, the EPA signed the final rule implementing Tier 4 emission standards which are to be phased-in over the period of 2008-2015 (69 Federal Register [FR] 38957-39273, 29 June 2004). The Tier 4 standards require that emissions of PM and NO_X be further reduced by about 90 percent. Such emission reductions can be achieved through the use of advanced control technologies – including advanced exhaust gas after treatment similar to those required by the 2007-2010 standards for highway diesel engines.

The Code of Federal Regulations (CFR) Title 40 is divided into parts to address specific EPA programs. Regulations initiated by the Office of Air and Radiation (OAR) have historically all been located together in Parts 49 through 99. Within OAR, the Office of Transportation and Air Quality (OTAQ) has adopted emission standards for various types of highway and nonroad engines, which are generally in Parts 85 through 94. To address the need for more regulatory parts for new programs and write them in plain language, EPA has reserved a new set of parts – 1000 through 1299 – for future use. The first 100 of these parts are reserved for engine emission control programs from the OTAQ, with the intended distribution as follows (EPA 2012d):

> Part 1027 specifies certification fees for all engines, vehicles, and equipment.

> Part 1033 is the standard for locomotives.

> Part 1036 is the standard for heavy-duty highway engines.

> Part 1037 is the standard for heavy-duty highway vehicles.

> Part 1039 is the standard for land-based nonroad diesel engines.

- Part 1042 is the standard for marine diesel engines.
- Part 1043 describes the requirements that apply under MARPOL Annex VI for marine diesel engines, including in-use fuel requirements.
- Part 1045 is the standard for marine spark-ignition engines.
- Part 1048 is the standard for nonroad spark-ignition engines over 19 kilowatts that are not used in recreational vehicles.
- Part 1051 is the standard for recreational vehicles, including snowmobiles, all-terrain vehicles, and off-highway motorcycles.
- Part 1054 is the standard for nonroad spark-ignition engines at or below 19 kilowatts.
- Part 1060 specifies emission standards and test procedures for all types of nonroad engines.
- Part 1065 describes general provisions related to procedures for testing engines.
- Part 1066 describes general provisions related to procedures for testing vehicles.
- Part 1068 includes general compliance provisions.
- Part 1074 describes provisions related to preemption of state regulations.

Portable Equipment Registration Program (PERP)

The statewide PERP establishes a uniform program to regulate portable engines and portable engine-driven equipment units. Once registered in PERP, engines and equipment units may operate throughout the State of California without the need to obtain individual permits from local air districts such as BAAQMD, NSCAPCD, and MBUAPCD. Owners or operators of portable engines and certain types of equipment can register their units under the PERP in order to operate their equipment anywhere in the state. (CARB 2012c)

BAAQMD operates stipulated enforcement programs for owners and operators of portable equipment which does not comply with CARB's Portable Diesel Airborne Toxic Control Measure (ATCM) regulation. Under this rule, any portable diesel engine not registered in the PERP prior to January 1, 2006, is illegal, and may not be operated in California unless it meets the ATCM Tier requirements or has an operating permit issued by an air district.

BAAQMD Regulation 2, Sections 2-1-105 and 2-1-114 list types of portable equipment commonly used in construction as exempt from stationary source rule requirements provided that the equipment complies with all applicable requirements of the statewide PERP pursuant to 13 CCR, Division 3, Chapter 3, Article 5. The nine MVCAC District Programs are not subject to BAAQMD permitting requirements because the Programs would not involve any stationary air pollution sources that are subject to BAAQMD review, including engine-driven pumps, generators, and air compressors.

Air Toxics Control Measures

On July 26, 2007, CARB adopted a regulation to reduce DPM and NO_X emissions from in use (existing) off-road heavy-duty diesel vehicles in California. Such vehicles are used in construction, mining, and industrial operations. Not included in this category are locomotives, commercial marine vessels, marine engines over 50 horsepower, or recreational vehicles. The ATCM regulation supplements existing tiered emission standards for nonroad diesel engines in California (CARB 2012d).

Senate Bill 656

Senate Bill 656 is a planning requirement that calls for a plan and strategy for reducing $PM_{2.5}$ and PM_{10}. This bill requires CARB to identify, develop, and adopt a list of control measures to reduce the emissions of $PM_{2.5}$ and PM_{10} from new and existing stationary, mobile, and area sources. BAAQMD has developed particulate matter control measures and submitted plans to CARB that include lists of measures to reduce particulate matter. Under the plans, air districts are required to continue to assess $PM_{2.5}$ and PM_{10} emissions and their impacts.

For construction emissions of fugitive PM_{10}, California air districts have adopted a number of feasible control measures that can be reasonably implemented to significantly reduce fugitive PM_{10} emissions from construction. In general, most districts' approach to CEQA (California Environmental Quality Act) analyses of construction impacts is to emphasize implementation of effective and comprehensive control measures rather than detailed quantification of emissions.

Nuisance (Odors)

BAAQMD and MBUAPCD CEQA Air Quality Guidelines (BAAQMD 1999, MBUAPCD 2008), require an assessment of a project's potential to cause a public nuisance by subjecting surrounding land uses (receptors) to objectionable odors. Due to proximity, NSCAPCD generally follows the BAAQMD guidelines (NSCAPCD 2012).

Nuisance is a fundamental air pollution control rule across the state in all air districts, including NSCAPCD Rule 400 and MBUAPCD Rule 402, and typically contain the same language as BAAQMD Regulation 1, Rule 301 which states that "No person shall discharge from any source whatsoever such quantities of air contaminants or other material which cause injury, detriment, nuisance or annoyance to any considerable number of persons or the public; or which endangers the comfort, repose, health or safety of any such persons or the public, or which causes, or has a natural tendency to cause, injury or damage to business or property."

An objectionable odor problem is defined by BAAQMD Regulation 7, Rule 102 as when the Air Pollution Control Officer "receives odor complaints from ten or more complainants within a 90-day period, alleging that a person has caused odors perceived at or beyond the property line of such person and deemed to be objectionable by the complainants in the normal course of their work, travel, or residence." The assessment protocol includes projects that have the potential to cause odors or projects that may subject potential sensitive receptors to nearby existing or proposed land uses that emit objectionable odors.

Toxic Air Contaminants

A project with the potential to expose sensitive receptors (including residential areas) or the general public to substantial levels of toxic air contaminants, as designated by CARB under 17 CCR Section 93001, listed in BAAQMD's Toxic Air Contaminants Inventory (BAAQMD 2004), would be deemed to have a significant impact. This includes projects that would locate receptors near existing sources of toxic air contaminants, as well as projects that would place sources of toxic air contaminants near existing receptors.

Projects that have the potential to expose the public to toxic air contaminants in excess of the following thresholds would be considered to have a significant air quality impact for receptors within 1,000 feet of a source boundary. These thresholds, which are based on the 1999 BAAQMD CEQA Air Quality Guidelines, are as follows:

> Probability of contracting cancer for the Maximally Exposed Individual (MEI) which exceeds 10 in 1 million. The MEI is a hypothetical person exposed for 70 years continuously (24 hours per day, 365 days per year).

> Ground-level concentrations of chronic or acute noncarcinogenic toxic air contaminants which result in a Hazard Index greater than one for the MEI.

DPM is considered a toxic air contaminant in California (BAAQMD 2004). Due to the limited use of diesel-powered vehicles and equipment and wide geographic scope of the Programs, emissions of DPM would not be sufficient to pose a significant risk to sensitive receptors from MVC equipment operations.

General Conformity

A General Conformity determination is required for Federally sponsored, permitted, or funded actions in NAAQS nonattainment areas or in certain maintenance areas when the total direct and indirect net emissions of nonattainment pollutants (or their precursors) exceed specified thresholds (Clean Air Act Amendments of 1990 Section 176[c]). This regulation ensures that Federal actions conform to State Implementation Plans (SIPs) and agency NAAQS attainment plans.

As discussed in Section 2.3.1 and shown in Table 2-2, the Bay Area region is in federal nonattainment $PM_{2.5}$ and ozone. Thus, the emissions of nonattainment pollutants NO_X, VOCs, PM_{10}, and $PM_{2.5}$ would be subject to the Rule if the Programs were Federal actions. However, since the Programs are local actions and not Federally sponsored, permitted, or funded actions, General Conformity does not apply.

2.5 Standards of Significance

The programmatic environmental impact report (PEIR) addresses the following standards of significance as based on CEQA Guidelines Appendix G. Would the project:

> Conflict with or obstruct implementation of the applicable Air Quality Attainment Plan or Congestion Management Plan?

> Violate any stationary source air quality standard or contribute to an existing or projected air quality violation?

> Result in a net increase of any criteria pollutant for which the project region is nonattainment under an applicable federal or state ambient air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors)?

> Expose sensitive receptors to substantial pollutant concentrations?

> Create objectionable odors affecting a substantial number of people?

For this Program, determinations made with respect to significance criteria are documented in the PEIR.

BAAQMD CEQA Guidelines

On June 2, 2010, the Bay Area Air Quality Management District (BAAQMD) adopted new CEQA Air Quality Guidelines (BAAQMD 2012b) for consideration by lead agencies tasked with evaluating the air quality and climate change impacts of proposed new projects. The proposed guidelines superseded the December 1999 Guidelines. As guidelines, they did not comprise enforceable rules or regulations per se, nevertheless, the guidelines established new quantitative thresholds of significance for criteria and greenhouse gas emissions.

However, on March 5, 2012, the Alameda County Superior Court issued a judgment finding that the BAAQMD had failed to comply with CEQA when it adopted the thresholds of significance. The court did not determine whether the thresholds were valid on the merits, but found that the adoption of the thresholds was a project under CEQA. The court issued a writ of mandate ordering the BAAQMD to set aside the 2010 thresholds and cease dissemination of them until it had complied with CEQA. The BAAQMD is no longer recommending that the 2010 thresholds be used as a generally applicable measure of a project's significance. Lead agencies may continue to rely on the 1999 CEQA thresholds

and may continue to make determinations regarding the significance of an individual project's air quality impacts based on the substantial evidence in the record for that project.

For the PEIR, air quality impacts will be quantitatively assessed using significance thresholds established by BAAQMD in its 1999 CEQA Guidelines for nonattainment pollutants and USEPA for attainment pollutants, which are listed in Table 2-3. MBUAPCD thresholds are the same or higher than BAAQMD thresholds (MBUAPCD 2008), and Federal Prevention of Significant Deterioration (PSD) thresholds contained in 40 CFR 51.166(b)(23)(i) applicable to NSCAPCD are also higher than BAAQMD thresholds. Thus, the 1999 BAAQMD thresholds are the most stringent (lowest) quantitative criteria for assessing the potential for all Program impacts under CEQA.

2.6 Methodology

As described in Section 2.2.3, operation of onroad fleet vehicles, offroad all-terrain vehicles, watercraft, aircraft, portable equipment, and small equipment would result in emissions of criteria pollutants (NO_X, VOC, CO, SO_X, PM_{10}, $PM_{2.5}$) in engine exhaust. Detailed lists of equipment, estimated usage, and emission calculations are provided in Attachment A. Equipment lists and annual activity schedules were provided by the nine participating MVC Districts. Emission calculations were performed using the most recent and applicable emission factors published by CARB (2008a) and EPA (1973, 1991a, 1991b, 2011b, 2011c, 2012c).

Table 2-4 shows alternatives applicability by percentage as selected by the nine MVC Districts: surveillance, physical control, vegetation management, biological control, chemical control, or other non-chemical control tapping. Table 2-5 shows land uses associated with selected alternatives: residential, commercial, industrial, agricultural, and open space. As shown in Tables 2-4 and 2-5, not all alternatives or land uses are applicable in all Districts, nor are all options or activities under any applicable alternative.

2.7 Estimated Emissions

Tables 2-6 through 2-11 show estimated ongoing annual criteria emissions by alternative and District. Table 2-12 shows estimated combined annual emissions across all nine Districts. Table 2-13 shows estimated peak daily criteria emissions for applicable alternatives assuming simultaneous operations as a hypothetical and highly unlikely "worst case" scenario. Table 2-14 shows estimated highest quarterly and average daily criteria emissions for applicable alternatives assuming concurrent operations as "typical case", which is a more likely and realistic scenario.

As shown in Table 2-12, no annual thresholds (Table 2-3) would be exceeded by the Programs, either individually or collectively. As shown in Table 2-13, no individual MVC District would exceed "worst case" daily thresholds. As shown in Table 2-14, no "typical case" daily thresholds would likely be exceeded by the Programs, either individually or collectively. Due to the very wide spatial and temporal dispersion of the mobile emissions sources across the nine Service Area counties, no ambient air quality standards for any pollutant would be violated solely by MVC activities. Since the combined annual or average daily emissions of the nine Districts would not be significant, neither would the incremental contribution of each District.

Table 2-3 CEQA Significance Thresholds - BAAQMD (1999)

Applicability	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$
Operation, tons/year	15	CAAQS[(1)]	15	40[(2)]	15	10[(2)]
Operation, pounds/year	30,000	CAAQS[(1)]	30,000	80,000	30,000	20,000
Operation, pounds/day	80	CAAQS[(1)]	80	—	80	—
Construction, pounds/day	80	CAAQS[(1)]	80	—	80[(3)]	—

Sources: BAAQMD 1999, 2012b (see note 4), 40 CFR 51.166. On March 5, 2012 the Alameda County Superior Court issued a judgment finding that the District had failed to comply with CEQA when it adopted the thresholds of significance. The court did not determine whether the thresholds were valid on the merits, but found that the adoption of the thresholds was a project under CEQA. The court issued a writ of mandate ordering the District to set aside the 2010 thresholds and cease dissemination of them until the District had complied with CEQA. The District is no longer recommending that the 2010 thresholds be used as a generally applicable measure of a project's significance. Lead Districts may continue to rely on the District's 1999 thresholds and may continue to make determinations regarding the significance of an individual project's air quality impacts based on the substantial evidence in the record for that project.

Notes:

(1) No violation of CAAQS for CO (9 ppmv for 1 hour, 20 ppmv for 8 hours)

(2) Prevention of Significant Deterioration (PSD), annual only

(3) For construction projects, applies to exhaust emissions only, not fugitive dusts

Table 2-4 Districts' Selected Alternatives Applicability

Districts	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Non-Chemical Control
Alameda County MAD	12%	7%	—	1%	64%	16%
Alameda County VCSD	100%	—	—	—	—	—
Contra Costa County MVCD	16%	0.07%	0.13%	0.07%	61%	23%
Marin-Sonoma Counties MVCD	20%	5%	13%	21%	25%	15%
Napa County MAD	11%	13%	7%	2%	64%	4%
Northern Salinas Valley MAD	3%	6%	29%	7%	39%	15%
San Mateo County MVCD	11%	0%	30%	21%	13%	24%
Santa Clara County VCD	47%	3%	—	13%	37%	—
Solano County MAD	24%	—	—	0.03%	46%	30%
Nine Districts Composite	**27%**	**4%**	**9%**	**7%**	**39%**	**14%**

Sources: Nine Districts

Table 2-5 Land Uses Associated with Selected Alternatives

Districts	Residential	Commercial	Industrial	Agricultural	Open Space
Alameda County MAD	●	●	●	●	●
Alameda County VCSD	●	●			
Contra Costa County MVCD	●	●	●	●	●
Marin-Sonoma Counties MVCD	●	●	●	●	●
Napa County MAD	●	●	●	●	●
Northern Salinas Valley MAD	●	●	●	●	●
San Mateo County MVCD	●	●	●		●
Santa Clara County VCD	●	●	●	●	●
Solano County MAD	●	●	●	●	●

Sources: Nine Districts

Table 2-6 Estimated Annual Criteria Emissions for Surveillance Alternative

Districts	VOC lbs/year	CO lbs/year	NO_X lbs/year	SO_X lbs/year	PM_{10} lbs/year	$PM_{2.5}$ lbs/year
Alameda County MAD	44	1,051	44	1.4	4.1	2.7
Alameda County VCSD	148	1,392	138	2.3	19.4	12.5
Contra Costa County MVCD	38	521	35	0.7	4.8	3.1
Marin-Sonoma Counties MVCD	132	2,515	298	3.5	19.5	13.9
Napa County MAD	21	718	40	0.8	2.6	1.7
Northern Salinas Valley MAD	3	57	18	0.1	0.8	0.6
San Mateo County MVCD	365	7,550	321	10.2	38.5	24.9
Santa Clara County VCD	240	2,300	226	3.7	31.3	20.3
Solano County MAD	73	1,710	225	2.6	9.0	5.9
Nine Districts Totals	**1,065**	**17,813**	**1,345**	**25.2**	**130.1**	**85.6**

Sources: CARB 2008a, EPA (1973, 1991a, 1991b, 2011b, 2011c, 2012c)

Notes:

SCCVCD = Emissions for equipment use associated with rodent and wildlife trapping are reported under Surveillance

Table 2-7 Estimated Annual Criteria Emissions for Physical Control Alternative

Districts	VOC lbs/year	CO lbs/year	NO_X lbs/year	SO_X lbs/year	PM_{10} lbs/year	$PM_{2.5}$ lbs/year
Alameda County MAD	25	606	25	0.8	2.4	1.5
Alameda County VCSD	0	0	0	0.0	0.0	0.0
Contra Costa County MVCD	0	2	0	0.0	0.0	0.0
Marin-Sonoma Counties MVCD	36	689	82	1.0	5.3	3.8
Napa County MAD	25	841	47	1.0	3.1	2.0
Northern Salinas Valley MAD	7	120	38	0.2	1.7	1.3
San Mateo County MVCD	8	170	7	0.2	0.9	0.6
Santa Clara County VCD	16	149	15	0.2	2.0	1.3
Solano County MAD	0	0	0	0.0	0.0	0.0
Nine Districts Totals	**117**	**2,577**	**214**	**3.4**	**15.4**	**10.5**

Sources: CARB 2008a, EPA (1973, 1991a, 1991b, 2011b, 2011c, 2012c)

Table 2-8 Estimated Annual Criteria Emissions for Vegetation Management Alternative

Districts	VOC lbs/year	CO lbs/year	NO_X lbs/year	SO_X lbs/year	PM_{10} lbs/year	$PM_{2.5}$ lbs/year
Alameda County MAD	0	0	0	0.0	0.0	0.0
Alameda County VCSD	0	0	0	0.0	0.0	0.0
Contra Costa County MVCD	0	4	0	0.0	0.0	0.0
Marin-Sonoma Counties MVCD	89	1,700	201	2.4	13.2	9.4
Napa County MAD	14	456	26	0.5	1.7	1.1
Northern Salinas Valley MAD	30	540	173	0.7	7.4	5.9
San Mateo County MVCD	973	20,105	855	27.0	102.6	66.4
Santa Clara County VCD	0	0	0	0.0	0.0	0.0
Solano County MAD	0	0	0	0.0	0.0	0.0
Nine Districts Totals	**1,106**	**22,805**	**1,255**	**30.7**	**124.9**	**82.9**

Sources: CARB 2008a, EPA (1973, 1991a, 1991b, 2011b, 2011c, 2012c)

Table 2-9 Estimated Annual Criteria Emissions for Biological Control Alternative

Districts	VOC lbs/year	CO lbs/year	NO_X lbs/year	SO_X lbs/year	PM_{10} lbs/year	$PM_{2.5}$ lbs/year
Alameda County MAD	3	67	3	0.1	0.3	0.2
Alameda County VCSD	0	0	0	0.0	0.0	0.0
Contra Costa County MVCD	0	2	0	0.0	0.0	0.0
Marin-Sonoma Counties MVCD	141	2,683	318	3.7	20.8	14.8
Napa County MAD	3	109	6	0.1	0.4	0.3
Northern Salinas Valley MAD	7	130	42	0.2	1.8	1.4
San Mateo County MVCD	669	13,828	588	18.6	70.5	45.7
Santa Clara County VCD	66	636	62	1.0	8.7	5.6
Solano County MAD	0	2	0	0.0	0.0	0.0
Nine Districts Totals	**890**	**17,458**	**1,019**	**23.7**	**102.5**	**68.0**

Sources: CARB 2008a, EPA (1973, 1991a, 1991b, 2011b, 2011c, 2012c)

Table 2-10 Estimated Annual Criteria Emissions for Chemical Control Alternative

Districts	VOC lbs/year	CO lbs/year	NO_X lbs/year	SO_X lbs/year	PM_{10} lbs/year	$PM_{2.5}$ lbs/year
Alameda County MAD	231	5,523	229	7.4	21.6	14.0
Alameda County VCSD	0	0	0	0.0	0.0	0.0
Contra Costa County MVCD	146	2,013	136	2.9	18.6	12.1
Marin-Sonoma Counties MVCD	167	3,168	375	4.4	24.5	17.5
Napa County MAD	127	4,244	238	4.9	15.6	10.1
Northern Salinas Valley MAD	41	737	236	1.0	10.2	8.1
San Mateo County MVCD	431	8,907	379	12.0	45.4	29.4
Santa Clara County VCD	186	1,786	175	2.9	24.3	15.7
Solano County MAD	138	3,235	426	4.8	17.1	11.1
Nine Districts Totals	**1,467**	**29,613**	**2,194**	**40.2**	**177.4**	**118.0**

Sources: CARB 2008a, EPA (1973, 1991a, 1991b, 2011b, 2011c, 2012c)

Table 2-11 Estimated Annual Criteria Emissions for Other Non-Chemical Control/Trapping Alternative

Districts	VOC lbs/year	CO lbs/year	NO_X lbs/year	SO_X lbs/year	PM_{10} lbs/year	$PM_{2.5}$ lbs/year
Alameda County MAD	58	1,374	57	1.8	5.4	3.5
Alameda County VCSD	0	0	0	0.0	0.0	0.0
Contra Costa County MVCD	56	774	52	1.1	7.2	4.6
Marin-Sonoma Counties MVCD	99	1,873	222	2.6	14.5	10.3
Napa County MAD	7	236	13	0.3	0.9	0.6
Northern Salinas Valley MAD	16	284	91	0.4	3.9	3.1
San Mateo County MVCD	755	15,609	664	21.0	79.6	51.6
Santa Clara County VCD	0	0	0	0.0	0.0	0.0
Solano County MAD	92	2,151	283	3.2	11.4	7.4
Nine Districts Totals	**1,082**	**22,300**	**1,382**	**30.4**	**122.8**	**81.1**

Sources: CARB 2008a, EPA (1973, 1991a, 1991b, 2011b, 2011c, 2012c)

Notes:

ACMAD = Emissions associated with ongoing District office administration and grounds maintenance activities are reported under this alternative.

SCCVCD = Emissions for equipment use associated with rodent and wildlife trapping are reported under Surveillance.

SCMAD = Emissions referenced in the "Other Non-Chemical" category emanate from vehicles and equipment used in connection with district activities not directly related to mosquito control, such as transportation to various meetings and facilities maintenance.

Table 2-12 Estimated Combined Annual Criteria Emissions Across Nine Districts

Alternatives	VOC tons/yr	CO tons/yr	NO_X tons/yr	SO_X tons/yr	PM_{10} tons/yr	$PM_{2.5}$ tons/yr
Surveillance	0.53	8.91	0.67	0.01	0.07	0.04
Physical Control	0.06	1.29	0.11	0.00	0.01	0.01
Vegetation Management	0.55	11.40	0.63	0.02	0.06	0.04
Biological Control	0.45	8.73	0.51	0.01	0.05	0.03
Chemical Control	0.73	14.81	1.10	0.02	0.09	0.06
Other Non-Chemical	0.54	11.15	0.69	0.02	0.06	0.04
All Alternatives Totals	**2.86**	**56.28**	**3.70**	**0.08**	**0.34**	**0.22**

Sources: CARB 2008a, EPA (1973, 1991a, 1991b, 2011b, 2011c, 2012c)

Table 2-13 Estimated Peak Daily Criteria Emissions for Applicable Alternatives - Simultaneous Operations

Districts	VOC lbs/day	CO lbs/day	NO_X lbs/day	SO_X lbs/day	PM_{10} lbs/day	$PM_{2.5}$ lbs/day
Alameda County MAD	5.8	177.5	39.9	0.3	0.9	0.6
Alameda County VCSD	0.6	5.5	0.6	0.0	0.1	0.0
Contra Costa County MVCD	7.8	152.7	23.7	0.2	1.2	0.8
Marin-Sonoma Counties MVCD	15.3	394.0	44.1	0.5	2.1	1.5
Napa County MAD	6.6	255.0	31.2	0.3	0.9	0.6
Northern Salinas Valley MAD	1.7	31.1	10.0	0.0	0.4	0.3
San Mateo County MVCD	25.3	810.2	31.8	1.0	2.1	1.4
Santa Clara County VCD	2.7	26.9	3.0	0.0	0.4	0.2
Solano County MAD	9.2	283.7	43.8	0.4	1.2	0.8
Peak Total Daily Emissions	**75**	**2,137**	**228**	**3**	**9**	**6**

Sources: CARB 2008a, EPA (1973, 1991a, 1991b, 2011b, 2011c, 2012c)

Table 2-14 Estimated Highest Quarterly Criteria Emissions for Applicable Alternatives - Concurrent Operations

Districts	VOC lbs/qtr	CO lbs/qtr	NO_X lbs/qtr	SO_X lbs/qtr	PM_{10} lbs/qtr	$PM_{2.5}$ lbs/qtr
Alameda County MAD	184	5,215	197	7	15	10
Alameda County VCSD	38	355	35	1	5	3
Contra Costa County MVCD	105	1,627	105	2	13	9
Marin-Sonoma Counties MVCD	223	4,369	485	6	33	23
Napa County MAD	79	3,114	168	3	10	6
Northern Salinas Valley MAD	30	493	177	1	8	6
San Mateo County MVCD	1,329	28,290	1,125	38	140	91
Santa Clara County VCD	145	1,383	136	2	19	12
Solano County MAD	136	3,702	413	5	15	10
Nine Districts Totals	**2,268**	**48,549**	**2,841**	**65**	**258**	**170**
Average Total Daily Emissions	**35**	**747**	**44**	**1**	**4**	**3**

Sources: CARB 2008a, EPA (1973, 1991a, 1991b, 2011b, 2011c, 2012c)

3 Greenhouse Gases and Climate Change

3.1 Introduction

Climate change refers to any significant change in the measures of climate lasting for an extended period of time, and includes major changes in temperature, precipitation, or wind patterns, among other effects, that occur over several decades or longer. The average temperature of the Earth has increased about 1.4°F (0.8°C) over the past century, and is projected to rise another 2 degrees to 11.5°F (1.1 to 6.4°C) over the next 100 years. Small changes in the average temperature of the planet can translate to large and potentially hazardous shifts in climate and weather. Climate change is suspected as the cause of changes in rainfall, resulting in more floods, droughts, or intense rain, as well as more frequent and severe heat waves. Also, oceans are warming and becoming more acidic, polar ice caps are melting, glaciers are receding, and sea levels are rising due to thermal expansion and ice loss. As climate change progresses in the coming decades, it will likely present challenges to society and the environment. (EPA 2012e)

Over the past century, human activities have released large amounts of carbon dioxide and other greenhouse gases (GHGs) into the atmosphere. The majority of greenhouse gases are the byproduct of burning fossil fuels to release energy in the form of heat, although deforestation, industrial processes, and some agricultural practices also emit greenhouse gases into the atmosphere. Greenhouse gases trap solar energy in the atmosphere and cause it to warm. This phenomenon is called the greenhouse effect and is necessary to support life on Earth, however, excessive buildup of greenhouse gases can change Earth's climate and result in undesirable effects on ecosystems, which affects human health and welfare. (EPA 2012e)

3.2 Environmental Setting

3.2.1 The Atmosphere

Air is a mixture of constituent gases and its composition varies slightly with location and altitude. For 20th century scientific and engineering purposes, it became necessary to define a standard composition known as the U.S. Standard Atmosphere. In addition to the common gases (nitrogen, oxygen, carbon dioxide, methane, hydrogen, nitrous oxide), the atmosphere contains noble or inert gases (argon, neon, helium, krypton, xenon). Radon (Rn) is also present in low concentrations near ground level in limited geographic areas where it is naturally emitted from certain types of rock and soil. Table 3-1 shows the typical composition of dry standard air, which is over 99 percent nitrogen and oxygen (UIG 2008; EPA 2012b). The apparent molecular weight of dry standard air is 28.966 grams per mole (Jennings 1970; du Pont 1971).

The atmosphere consists of five basic altitude zones: troposphere (sea level to 8 miles); stratosphere (8 to 32 miles); mesosphere (32 to 50 miles); thermosphere (50 to 350 miles); and exosphere (350 to 500 miles). Within the stratosphere is the ozone layer (9 to 22 miles) which absorbs ultraviolet wavelengths; and within the mesosphere is the ionosphere (62 to 190 miles) which reflects shortwave radio signals and produces auroras. These approximate altitude ranges vary with latitude, season, solar activity, and turbulence. Greenhouse gases persist mainly in the troposphere and stratosphere – some in the mesosphere – for different lengths of time, ranging from less than 5 years to over 50,000 years, long enough to become well-mixed, meaning that atmospheric concentrations are about the same all over the world, regardless of source locations (EPA 2012f). Thus, the homogeneous composition of the lower atmosphere is the global setting for climate change.

Table 3-1 Standard Composition of Dry Air

Principal Gas	Chemical Symbol	Gas MW g/mole	Concentration ppmv	Fraction percent	Fraction MW g/mole
Nitrogen	N_2	28.014	780,805.00	78.080500	21.873471
Oxygen	O_2	31.998	209,440.00	20.944000	6.701661
Argon	Ar	39.948	9,340.00	0.934000	0.373114
Carbon Dioxide	CO_2	44.009	387.69	0.038769	0.017062
Neon	Ne	20.183	18.21	0.001821	0.000368
Helium	He	4.003	5.24	0.000524	0.000021
Methane	CH_4	16.043	1.81	0.000181	0.000029
Krypton	Kr	83.800	1.14	0.000114	0.000096
Hydrogen	H_2	2.016	0.50	0.000050	0.000001
Nitrous Oxide	N_2O	44.013	0.32	0.000032	0.000014
Xenon	Xe	31.300	0.09	0.000009	0.000003
Totals			**1,000,000.00**	**100.000**	**28.966**

Sources: UIG 2008, EPA 2012b, du Pont 1971, Jennings 1970

Notes:

MW = molecular weight, g/mole

ppmv = parts per million by volume (10^{-6})

3.2.2 Area Climate

The Program Areas' climate is characterized by moderately wet winters and dry summers. About 90 percent of the annual total rainfall is received in the November through April period. Between June and September, normal rainfall is typically less than 0.6 inch (1.5 centimeters). Temperatures in the Program Area average about 60°F (15°C) annually, with average summer highs in the 70 to 80°F (21 to 27°C) range and average winter lows in the 40 to 50°F (4 to 10°C) range. Precipitation averages about 23 inches (58 centimeters) per year, although annual precipitation can vary significantly from year-to-year. Annual average wind speeds in the Program Areas are about 8 miles per hour (3.6 meters per second). The predominant direction of air pollution transport in the Program Areas is inland from the coastal areas (BAAQMD 2010a, WC 2012, NOAA 2008).

3.3 Greenhouse Gases

3.3.1 Principal GHGs

Gases that trap heat in the atmosphere are called greenhouse gases or GHGs. Principal GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and other fluorinated gases including nitrogen trifluoride and hydrofluorinated ethers. Greenhouse gases occur naturally because of volcanoes, forest fires, and biological processes such as enteric fermentation and aerobic decomposition. They are also produced by combustion of fuels, industrial processes, agricultural operations, waste management, and land use changes such as loss of farmland to urbanization. The most common GHG from human activity (fuel combustion) is CO_2, followed by CH_4 and N_2O. (EPA 2012f)

Concentration, or abundance, is the amount of a particular gas in the air. Larger emissions of greenhouse gases lead to higher concentrations in the atmosphere. Greenhouse gas concentrations are measured in units of parts per million (ppm), parts per billion (ppb), and parts per trillion (ppt). One part per million is equivalent to one cubic centimeter (cc) of pure gas diluted in one cubic meter of air. Similarly, one part per billion is one cc diluted in 1,000 cubic meters, and one part per trillion is one cc diluted in 1,000,000 cubic meters. (EPA 2012f)

Carbon Dioxide

Carbon dioxide (CO_2) enters the atmosphere through burning fossil fuels (coal, natural gas, and petroleum products), decomposition of solid waste, trees and wood products, fermentation, and also as a result of certain chemical reactions, such as manufacture of cement. Carbon dioxide is removed from the atmosphere (or "sequestered") when it is absorbed by plants as part of the biologic carbon cycle. In the carbon cycle, carbon in various molecular forms is cycled among atmospheric, oceanic, land biotic, marine biotic, and mineral reservoirs. Atmospheric carbon dioxide is part of this global carbon cycle. Carbon dioxide concentrations in the atmosphere have increased from about 280 ppm in pre-industrial times to about 390 ppm today, a 39 percent increase. The Intergovernmental Panel on Climate Change (IPCC), notes that "this concentration has not been exceeded during the past 420,000 years, and likely not during the past 20 million years. The rate of increase over the past century is unprecedented, at least during the past 20,000 years." The IPCC definitively states that "the present atmospheric CO_2 increase is caused by anthropogenic emissions of CO_2". (EPA 2012f, IPCC 2007)

Global Warming Potential (GWP) is a quantified measure of the globally averaged relative radiative forcing impacts of a particular GHG. It is defined as the cumulative radiative forcing both direct and indirect effects integrated over a period of time from the emission of a unit mass of gas relative to a reference gas. Carbon dioxide is the reference gas with a GWP of unity (1). Carbon dioxide equivalents (CO_2e) are calculated by summing the products of mass GHG emissions by species times their respective U.S. Environmental Protection Agency (EPA) official GWP coefficients. The persistence of CO_2 in the atmosphere is estimated to be in the range of 50 to 200 years, depending on variations in the carbon cycle. (EPA 2012b, EPA 2012f)

Methane

Methane (CH_4) is primarily produced through anaerobic decomposition of organic matter in biological systems. Agricultural processes such as wetland rice cultivation, enteric fermentation in ruminant animals (e.g., cows), and the decomposition of animal wastes emit methane, as does the decomposition of municipal solid wastes. Methane is also fugitively emitted during the production and distribution of natural gas and petroleum, and is released as a by-product of coal mining and incomplete fossil fuel combustion. Pipeline-quality natural gas is over 90 percent methane by volume and is considered a "clean fuel" by industry with carbon dioxide and water vapor as its main combustion byproducts. Atmospheric concentrations of methane have increased by about 160 percent since pre-industrial times, although the rate of increase has been declining. The IPCC has estimated that slightly more than half of the current methane flux to the atmosphere is anthropogenic, from human activities such as agriculture, fossil fuel use, and waste disposal. The EPA's official GWP coefficient of CH_4 is 21, and its persistence in the atmosphere is estimated to be about 9 to 15 years. (EPA 2012b, EPA 2012f)

Nitrous Oxide

Nitrous oxide (N_2O) is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste. Anthropogenic sources of nitrous oxide emissions include agricultural soils, especially the use of synthetic and manure fertilizers; fossil fuel combustion, especially from mobile combustion; adipic (nylon) and nitric acid production; wastewater treatment and waste combustion; and biomass burning. The atmospheric concentration of N_2O has increased by about 19 percent since 1750, from a pre-industrial value of about 270 ppb to about 320 ppb today, a concentration that has not been

exceeded during the last thousand years. The EPA's official GWP coefficient of N_2O is 310, and its persistence in the atmosphere is estimated to be about 110 to 120 years. (EPA 2012b, EPA 2012f)

Fluorinated gases

Hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride are synthetic, powerful greenhouse gases that are emitted from a variety of industrial processes. Fluorinated gases are sometimes used as substitutes for ozone-depleting substances (e.g., chlorofluorocarbons, hydrochlorofluorocarbons, and halons). In the electric utility industry, sulfur hexafluoride (SF_6) is used as a dielectric gas in high-voltage equipment, such as switchgear and circuit breakers. As man-made gas, SF_6 in the atmosphere has increased from 0 to about 7 ppt in modern times. Due to their expense, all of these fluorinated gases are typically emitted (lost) in small quantities relative to combustion byproducts, but because they are potent greenhouse gases, they are sometimes referred to as "High GWP gases" with estimated persistence in the atmosphere ranging from 1.5 to 50,000 years. Of these, SF_6 is the most potent, with an EPA official GWP of 23,900 and an estimated persistence of about 3,200 years. (EPA 2012b, EPA 2012f)

3.3.2 Emission Sources

The EPA tracks greenhouse gas emissions in the United States and publishes the *Inventory of U.S. Greenhouse Gas Emissions and Sinks*, which is updated annually (EPA 2012d). This detailed report contains estimates of the total national greenhouse gas emissions and removals associated with human activities in all 50 states. From the current report, the main sources of greenhouse gas emissions in the United States are identified below (EPA 2012f):

> Electric power generation accounts for 34 percent of GHG emissions nationwide. Over 70 percent of electric power is generated by burning fossil fuels, mainly coal and natural gas. Greenhouse gas emissions from electric power generation in the United States have increased by about 24 percent since 1990 as demand for electric power has grown and fossil fuels have remained the dominant energy source for generation due to their low cost and high reliability.

> Transportation accounts for 27 percent of GHG emissions nationwide. Greenhouse gas emissions from transportation result from burning fossil fuels in automobiles, trucks, trains, ships, and aircraft. About 90 percent of the fuel used for transportation is petroleum-based, which includes gasoline, diesel, and jet fuel.

> Industry accounts for 21 percent of GHG emissions nationwide. Greenhouse gas emissions from industry are associated mainly with burning fossil fuels (coal, natural gas) for heat energy as well as emissions from certain chemical reactions necessary to produce goods from raw materials.

> Commercial and Residential uses account for 11 percent of GHG emissions nationwide. Greenhouse gas emissions from businesses and homes result primarily from fossil fuels burned for heat, the use of certain products that contain GHGs, and the handling and disposal of domestic wastes.

> Agriculture accounts for 7 percent of GHG emissions nationwide. Greenhouse gas emissions from agriculture are caused by livestock such as cows (enteric fermentation), soil management practices, and rice farming.

> Land Use and Forestry offsets (absorbs or sequesters) about 15 percent of GHG emissions nationwide. Land areas can act as GHG sinks (absorbing CO_2 from the atmosphere) or GHG sources. Since 1990, well-managed forests and other lands have absorbed more CO_2 from the atmosphere than they emit.

3.3.3 Emission Trends

Annual GHG emission inventories provide the basis for establishing historical emission trends. Trends are useful in tracking progress towards a specific goal or target. There are many factors affecting GHG emissions, including the state of the economy, changes in demography, improved efficiency, and changes in environmental conditions such as drought.

From 2000 to 2009, California's gross GHG emissions decreased by 1.5 percent overall from 464 to 457 million metric tonnes (MMT) CO_2e, with a maximum of 489 MMT CO_2 e in 2007. During the same period, California's population grew by 9.7 percent from 33.9 to 37.2 million, therefore, per capita GHG emissions decreased from 13.7 to 12.3 metric tonnes of CO_2 e per person. From 2008 to 2009, overall GHG emissions decreased by about 6 percent. This reflects the effect of the economic recession and higher fuel prices, with marked declines in on-road transportation, cement production, and electric power consumption. As the economy recovers, emissions are likely to rise again until GHG reduction measures begin to take effect. (CARB 2011a)

Since 1990, greenhouse gas emissions in the United States have increased by about 10 percent. however, from year-to-year emissions can increase or decrease due to changes in the economy, the price of fuel, weather, and other factors. In 2010, national GHG emissions increased about 3 percent from 2009 levels. This increase was primarily due to the improving economy which increased energy consumption across all sectors. In addition, a hot summer caused an increase in electric power demand for air conditioning that was generated mainly by burning coal and natural gas in existing power plants. (EPA 2012f)

3.3.4 Mobile Sources

While stationary sources such as power plants and oil refineries emit large quantities of greenhouse gases, mobile sources, due their sheer numbers nationwide, also emit significant amounts. Mobile sources include onroad vehicles (e.g., automobiles, trucks, motorcycles), offroad equipment (e.g., earthmovers, cranes, portable pumps and generators), trains (e.g., freight, passenger, light rail), vessels (e.g., boats, ships, watercraft), and aircraft (e.g., general aviation, commercial, military). Mobile source fuels include gasoline, diesel, heavy fuel oil (large marine vessels), and jet fuel, all of which emit GHGs when combusted.

Mobile sources used in mosquito and vector control (MVC) activities include onroad fleet vehicles (light- and medium-duty trucks, vans, passenger cars), offroad all-terrain vehicles (ATVs), watercraft (motorboats, airboats), aircraft (helicopters and fixed-wing), portable equipment (pumps, sprayers, generators), and small equipment (hand-held sprayers, foggers, dusters). Except for 2-stroke engines used in small lightweight equipment (spark ignition, 50:1 gas/oil mix), engines are 4-stroke gasoline (spark ignition) or diesel fuel (compression ignition). The dominant fuel used for these mobile sources is motor gasoline along with some diesel fuel (larger trucks) , aviation gasoline (fixed-wing aircraft), and jet fuel (turbine-powered helicopters). Light trucks, vans, and passenger cars are normally used for responding to public service requests and disease surveillance. Typical GHG contents of common fuels are presented in Table 3-2.

Table 3-2 Typical GHG Contents of Common Fuels

Fuel	CO_2 kg/mmBTU	CH_4 kg/mmBTU	N_2O kg/mmBTU	CO_2e lb/mmBTU	Energy BTU/gal	CO_2e lb/gal
Diesel Fuel No. 2	73.96	0.0105	0.0006	163.97	138,300	22.68
Kerosene	73.19	0.0105	0.0006	162.27	138,700	22.51
Jet Fuel	72.23	0.0105	0.0006	160.17	135,000	21.62
Motor Gasoline	71.35	0.0105	0.0006	158.23	122,600	19.40
Aviation Gasoline	69.15	0.0105	0.0006	153.38	120,200	18.44
Propane	62.22	0.0053	0.0001	137.49	91,300	12.55
Pipeline Natural Gas	53.02	0.0053	0.0001	117.20	—	—

Sources: EPA 2012b, EPA 2011b

Notes:

kg/mmBTU = kilograms per million British Thermal Units

lb/mmBTU = pounds per million British Thermal Units

BTU = the amount of energy (heat) required to raise 1 pound of liquid water 1 degree Fahrenheit from 39 to 40°F

3.3.5 Sensitive Receptors

Certain population groups are considered more sensitive to air pollution and odors than others; in particular, children, elderly, and acutely ill and chronically ill persons, especially those with cardio respiratory diseases such as asthma and bronchitis. Sensitive receptors (land uses) indicate locations where such individuals are typically found, namely schools, daycare centers, hospitals, convalescent homes, residences of sensitive persons, and parks with active recreational uses, such as youth sports.

Persons engaged in strenuous work or physical exercise also have increased sensitivity to poor air quality. Residential areas are considered more sensitive to air quality conditions than commercial and industrial areas, because people generally spend longer periods of time at their residences, resulting in greater exposure to ambient air quality conditions. Recreational uses such as parks are also considered sensitive, due to the greater exposure to ambient air quality conditions and because the presence of pollution detracts from the recreational experience.

None of the greenhouse gases described in Section 3.3.1 are considered toxic, however, all are classified as asphyxiants. Thus, in high enough concentrations in confined spaces they can displace the oxygen in air and present hazards to industrial workers, however, GHG concentrations in ambient air (see Table 3-1) are far below any danger levels. Therefore, no risk to sensitive receptors or the general public is posed by greenhouse gases emitted to outdoor air, either from stationary or mobile sources.

3.4 Climate Change

3.4.1 National and International Assessments

The American Meteorological Society refers to climate change as any systematic change in the long-term statistics of climate elements (such as temperature, pressure, or winds) sustained over several decades or longer. The Society also indicates that climate change may be due to natural external forcings, such as changes in solar emission or slow changes in the Earth's orbital elements; natural internal processes of the climate system; or anthropogenic forcing (AMS 2012). The climate system can be influenced by changes in the concentration of various GHGs in the atmosphere that affect the Earth's absorption of radiation.

In its *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2011* (EPA 2012b), the EPA provides summary information on the work of the United Nations Framework Convention on Climate Change (UNFCCC, 2009) and the Intergovernmental Panel on Climate Control (IPCC, 1990-2007); key information from that report is summarized below – more details may be found in the cited source documents.

The UNFCCC defines climate change as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" (UNFCCC 2009). In its *Second Assessment Report* of the science of climate change, the IPCC concluded "human activities are changing the atmospheric concentrations and distributions of greenhouse gases and aerosols" (IPCC 1995). These changes can produce a radiative forcing by changing either the reflection or absorption of solar radiation, or the emission and absorption of terrestrial radiation." Building on this conclusion, the IPCC *Third Assessment Report* (IPCC 2001) asserted "concentrations of atmospheric greenhouse gases and their radiative forcing have continued to increase as a result of human activities."

The IPCC reports the global average surface temperature of the Earth has increased by 1.1 ±0.4°F (0.6 ±0.2°C) over the 20th century. This value is about 0.27°F (0.15°C) larger than that estimated by the Second Assessment Report, which reported for the period up to 1994, "owing to the relatively high temperatures of the additional years (1995 to 2000) and improved methods of processing the data."

While the *Second Assessment Report* concluded, "the balance of evidence suggests there is a discernible human influence on global climate," the *Third Assessment Report* more directly connects the influence of human activities on climate. IPCC concluded, "In light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations."

In its most recent *Fourth Assessment Report*, IPCC stated warming of Earth's climate is unequivocal, and that warming is very likely attributable to increases in atmospheric greenhouse gases caused by human activities (IPCC 2007). IPCC further stated changes in many physical and biological systems, such as increases in global temperatures, more frequent heat waves, rising sea levels, coastal flooding, loss of wildlife habitat, spread of infectious disease, and other potential environmental impacts, are linked to changes in the climate system, and some changes might be irreversible.

The mobile sources used in MVC activities emit greenhouse gases and therefore contribute incrementally to climate change; however, as described in Section 3.8, these emissions comprise a very small fraction of the Bay Area, California, and U.S. GHG inventories. This fact precludes any meaningful analysis of quantitative effects that MVC operations may specifically have on climate, although taken together with regional, national, and worldwide GHG emissions, global effects are as described above.

3.4.2 State Policies

The Global Warming Solutions Act of 2006 (AB 32) (see Section 3.5.2 below) required the California Air Resources Board (CARB) to prepare a Scoping Plan to achieve substantial GHG emissions reductions, both from within the state and from "exported" emissions, such as importing electric power generated at coal-fired power plants located in neighboring western states. The 2008 Scoping Plan outlines a wide range of strategies for reducing statewide GHG emissions to 1990 levels by 2020. This will be achieved by cutting about 30 percent from business-as-usual emission levels projected for 2020, or about 15 percent from 2008 levels. Allowing for population growth, the goal is to reduce annual per capita emissions from 14 metric tonnes (MT) of CO_2e down to about 10 MT CO_2e per capita by 2020. (CARB 2008b)

3.4.3 Emissions Inventories

The bulk of MVC activity emissions would occur in the Bay Area, and only minor amounts would occur in northern Sonoma, Yolo, Solano, and northern Monterey counties. Therefore, the comprehensive 2007 Bay Area GHG inventory is used as the regional benchmark for comparison purposes.

Table 3-3 shows aggregated national, state, and regional GHG emissions for all sources on a gross basis, i.e., CO_2e emissions only, not including CO_2 sinks such as forestry and agriculture. As shown, California accounts for about 7 percent of gross CO_2e emissions in the U.S. annually, and the Bay Area accounts for about 20 percent of gross CO_2e emissions in California.

Tables 3-4, 3-5, 3-6, and 3-7 present progressively focused Bay Area GHG emissions inventory data for 2007 broken down by sectors, counties, and applicable sub-sectors. This information will be used as a basis for comparisons with estimated MVC activity emissions for the nine Districts presented in Section 3.8.

Table 3-3 Greenhouse Gas Emissions Inventories - Gross Basis

Summary Year	National MMT CO_2e	California MMT CO_2e	Bay Area MMT CO_2e
2005	7,204	482.5	—
2006	7,159	481.9	—
2007	7,253	488.8	95.8
2008	7,048	484.7	—
2009	6,608	456.8	—
5-Year Average	**7,054**	**478.9**	—
Average Annual Variation	**2.6%**	**1.8%**	—

Sources: EPA 2012b, CARB 2011b, BAAQMD 2010b

Notes:

MMT - million metric tonnes (annual)

1 metric tonne = 1,000 kilograms or 2,204.6 pounds

2009 is most recent CARB published data; Bay Area for 2007 only

Table 3-4 Bay Area GHG Emissions by Sector

	District Emissions	
End-Use Sector	**Percent**	**MMT CO_2e**
Industrial / Commercial	36.4%	34.9
Residential Fuel Use	7.1%	6.8
Local Electric Power Generation	8.5%	8.1
Imported Electric Power Generation	7.4%	7.1
Offroad Equipment	3.0%	2.9
Transportation	36.4%	34.9
Agriculture / Farming	1.2%	1.1
Totals	**100.0%**	**95.8**

Source: BAAQMD 2010b

Notes:

MMT - million metric tonnes (annual)

1 metric tonne = 1,000 kilograms or 2,204.6 pounds

Table 3-5 Bay Area GHG Emissions by County

County	District Emissions	
	Percent	**MMT CO_2e**
Alameda	16.4%	15.7
Contra Costa	32.9%	31.5
Marin	2.8%	2.7
Napa	1.8%	1.7
San Francisco	7.4%	7.1
San Mateo	8.9%	8.5
Santa Clara	19.6%	18.8
Solano (within BAAQMD)	5.9%	5.7
Sonoma (within BAAQMD)	4.3%	4.1
Totals	**100.0%**	**95.8**

Source: BAAQMD 2010b

Notes:

MMT = million metric tonnes (annual)

1 metric tonne = 1,000 kilograms or 2,204.6 pounds

Table 3-6 Mobile Sectors GHG Emissions by County

County	Offroad MT CO_2e	Transportation MT CO_2e
Alameda	569,000	8,351,000
Contra Costa	406,000	4,998,000
Marin	99,000	1,286,000
Napa	50,000	917,000
San Francisco	415,000	2,673,000
San Mateo	270,000	4,850,000
Santa Clara	790,000	7,859,000
Solano (within BAAQMD)	147,000	1,834,000
Sonoma (within BAAQMD)	175,000	2,103,000
Totals	**2,921,000**	**34,871,000**

Source: BAAQMD 2010b

Notes:

MT = metric tonnes (annual)

1 metric tonne = 1,000 kilograms or 2,204.6 pounds

Values rounded to nearest 1,000 tonnes

"Offroad" is offroad equipment category

Table 3-7 Offroad Sub-Sectors GHG Emissions by County

County	Utility MT CO_2e	Commercial MT CO_2e	Combined MT CO_2e
Alameda	29,800	49,900	79,700
Contra Costa	20,300	26,900	47,200
Marin	7,900	12,300	20,200
Napa	2,900	4,300	7,200
San Francisco	14,200	43,900	58,100
San Mateo	14,200	27,200	41,400
Santa Clara	32,900	56,500	89,400
Solano (within BAAQMD)	3,900	6,800	10,700
Sonoma (within BAAQMD)	7,800	13,500	21,300
Totals	**133,900**	**241,300**	**375,200**

Source: BAAQMD 2010b

Notes:

MT= metric tonnes (annual)

1 metric tonne = 1,000 kilograms or 2,204.6 pounds

Values rounded to nearest 100 tonnes

"Utility" is small landscaping equipment selected for comparisons to Districts' activities

"Commercial" is light commercial equipment selected for comparisons to Districts' activities

3.5 Regulatory Setting

Currently, no local, state, or Federal regulatory standards directly apply to GHG emissions from temporary or intermittent mobile sources such as MVC activities. However, in the context of the Scoping Plan discussed in Section 3.4.2, implementation of Low Carbon Fuel Standard (Executive Order S-1-07, below) would indirectly apply to MVC activities via fuel usage. Summaries of principal Federal, state, and local GHG statutes, regulations, and programs which affect other types of sources are presented below.

3.5.1 Federal

40 CFR Part 98 – Greenhouse Gas Reporting

On October 30, 2009 the EPA issued the Mandatory Reporting of Greenhouse Gases rule (74 FR 56260, 40 CFR 98, effective December 29, 2009) which requires reporting of GHG data and other relevant information from large sources and suppliers in the United States pursuant to Fiscal Year 2008 Consolidated Appropriations Act (HR 2764; Public Law 110-161).

The new rule facilitates collection of accurate and comprehensive emissions data to provide a basis for future EPA policy decisions and regulatory initiatives. The rule requires specified industrial source categories and facilities with an aggregated heat input of 30 mmBTU or more per hour or that emit 25,000 metric tons or more per year of GHG to submit annual reports to the EPA. The gases covered by the rule are CO_2, CH_4, N_2O, and HFCs, PFCs, SF_6, and other fluorinated gases including nitrogen trifluoride and hydrofluorinated ethers. Since the Programs do not meet the definition of an affected stationary source (i.e., mobile sources only), the GHG reporting rule does not apply.

Notwithstanding the GHG reporting rule, no Federal regulations currently limit or curtail GHG emissions of carbon dioxide and methane, and EPA cap-and-trade programs currently apply only to acid rain

precursors sulfur dioxide (SO_2) and nitrogen oxides (NO_X) (EPA 2012g). However, emissions of N_2O are regulated, albeit indirectly, through limitation of NO_X emissions as a criteria pollutant under New Source Performance Standards (NSPS) and Federal, state, and local operating permits.

General Conformity

A General Conformity determination is required for Federally sponsored, permitted, or funded actions in NAAQS nonattainment areas or in certain maintenance areas when the total direct and indirect net emissions of nonattainment pollutants (or their precursors) exceed specified thresholds (Clean Air Act Amendments of 1990 Section 176[c]). This regulation ensures that Federal actions conform to State Implementation Plans (SIPs) and agency NAAQS attainment plans. Since greenhouse gases are not regulated criteria air pollutants and the Programs are not Federally sponsored, permitted, or funded actions, General Conformity does not apply.

3.5.2 State

Global Warming Solutions Act

The Global Warming Solutions Act of 2006 (Assembly Bill [AB] 32) codifies California's goal of reducing statewide emissions of GHGs to 1990 levels by 2020. This reduction will be accomplished through an enforceable statewide cap on global warming emissions that will be phased in starting in 2012 to achieve maximum technologically feasible and cost-effective GHG emission reductions. In order to effectively implement the cap, AB 32 directs the California Air Resources Board (CARB) to develop appropriate regulations and establish a mandatory reporting system to track and monitor global warming emissions levels.

On September 25, 2009, CARB adopted the AB 32 Cost of Implementation Fee Regulation (Health and Safety Code 38597). The regulation was approved by the Office of Administrative Law on June 17, 2010, and became effective on July 19, 2010. For the first year of the fee program, CARB will administratively provide compliance flexibility and will not enforce reporting and fee requirements until after the passage of the state budget for fiscal year 2010-11. Until the budget is enacted and CARB provides detailed compliance criteria, facilities subject to the regulation do not need to pay fees or report information required by the regulation. However, since the Programs are not affected stationary sources, the AB 32 fee regulation does not apply.

Cap and Trade

The California Air Resources Board's new "Cap and Trade" regulation (Subchapter 10, Article 5, Sections 95800 to 96023, Title 17, California Code of Regulations) is a set of rules (effective September 1, 2012) that establishes a limit on GHG emissions from the largest sources of GHGs in the state. The purpose of *California Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanisms* is to reduce emissions of GHGs from affected stationary sources through the establishment, administration, and enforcement of an aggregate GHG allowance budget and to provide a trading mechanism for compliance instruments (i.e., "GHG allowances" or "carbon credits"). Since the Programs are not affected stationary sources under the rule, Cap and Trade does not apply. No other statewide quantitative standards of significance for GHG impacts have been established for nonaffected sources under CEQA.

Assembly Bill 939

California AB 939, known as the Integrated Waste Management Act of 1989, was enacted due to increasing waste stream volumes and decreasing landfill capacities in the state. As a result of AB 939, the California Integrated Waste Management Board was created. A disposal reporting system with its oversight was established, and facility and program planning was required. AB 939 mandated that sanitation districts (jurisdictions) meet diversion goals of 25 percent by 1995 and 50 percent by 2000, primarily through recyclables collection and green waste compositing. AB 939 also established an

integrated framework for program implementation, solid waste planning, and solid waste facility and landfill compliance.

Senate Bill 1368

California Senate Bill (SB) 1368 adds sections 8340 and 8341 to the Public Utilities Code (effective January 1, 2007) with the intent "to prevent long-term investments in power plants with GHG emissions in excess of those produced by a combined-cycle natural gas power plant" with the aim of "reducing emissions of GHGs from the state's electricity consumption, not just the state's electricity production." SB 1368 provides a mechanism for reducing the GHG emissions of electricity providers, both in-state and out-of-state, thereby assisting CARB in meeting its mandate under AB 32, the Global Warming Solutions Act of 2006.

Senate Bill 97

California SB 97 directs the Office of Planning and Research to prepare, develop, and transmit to the Resources Agency CEQA guidelines for the feasible mitigation of GHG emissions or their effects by July 1, 2009. The Resources Agency is required to certify or adopt those guidelines by January 1, 2010. SB 97 also protects, for a short time, certain projects funded by the Highway Safety, Traffic Reduction, Air Quality and Port Security Bond Act of 2006, or the Disaster Preparedness and Flood Protection Bond Act of 2006 (Proposition 1B or 1E) from claims of inadequate analysis of GHG as a legitimate cause of action. This latter provision was repealed on January 1, 2010.

Senate Bill 375

California SB 375 aims to reduce GHG emissions by curbing sprawl, because the largest sources of GHG emissions in California are passenger vehicles and light trucks. SB 375 provides emission reduction goals for which regions can plan, integrates disjointed planning activities, and provides incentives for local governments and developers to follow new conscientiously-planned growth patterns. SB 375 enhances CARB's ability to reach AB 32 goals by requiring metropolitan planning organizations to include defined sustainable community strategies in their regional transportation plans for the purpose of reducing GHG emissions, aligns planning for transportation and housing, and creates specified incentives for the implementation of the strategies.

Senate Bills 1078 and 10

California SB 1078 was signed into legislation in 2002 and required California load serving entities (electric utilities) to procure 20 percent of their retail customer load with renewable energy by the year 2017. Four years later (2006), SB 10 accelerated the 20 percent renewable deadline to 2010.

Executive Order S-20-04

On July 27, 2004, Executive Order S-20-04 was issued committing the state to aggressive action to reduce state-owned building electricity usage by retrofitting, building and operating the most energy and resource efficient buildings by taking all cost-effective measures described in the Green Building Action Plan with the goal of reducing grid-based energy purchases by 20 percent by 2015. This order also directed the California Public Utilities Commission to support a campaign to improve commercial building energy efficiency in order to help achieve the 20 percent goal and to develop a benchmarking methodology.

Executive Order S-3-05

On June 1, 2005, Executive Order S-3-05 was issued establishing GHG emission reduction targets: by 2010, reduce GHG emissions to 2000 levels; by 2020, reduce GHG emissions to 1990 levels; and by 2050, reduce GHG emissions to 80 percent below 1990 levels.

Executive Order S-1-07

On January 18, 2007, the Low Carbon Fuel Standard (LCFS) was issued mandating a reduction of at least 10 percent in the carbon intensity of California's transportation fuels by 2020. It instructed the California Environmental Protection Agency to coordinate activities among the University of California, the California Energy Commission, and other state agencies to develop and propose a draft compliance schedule to meet the 2020 target. Furthermore, it directed CARB to consider initiating regulatory proceedings to establish and implement the LCFS. In response, CARB identified the LCFS as an early action item with a regulation to be adopted and implemented by 2010.

Executive Order S-13-08

On November 14, 2008, Executive Order S-20-04 was issued directing the California Resources Agency, in cooperation with the Department of Water Resources, the California Energy Commission, California's coastal management agencies, and the Ocean Protection Council to request that the National Academy of Sciences convene an independent panel to complete the first California Sea Level Rise Assessment Report by December 1, 2010. As part of this effort, the Resources Agency is to create an independent sea level rise science and policy committee made up of state, national, and international experts and to hold public workshops to gather policy-relevant information.

3.5.3 Local

BAAQMD CEQA Guidelines

On June 2, 2010, the Bay Area Air Quality Management District (BAAQMD) adopted new CEQA Air Quality Guidelines (BAAQMD 2012b) for consideration by lead agencies tasked with evaluating the air quality and climate change impacts of proposed new projects. The proposed Guidelines superseded the December 1999 Guidelines. As guidelines, they did not comprise enforceable rules or regulations per se, nevertheless, the guidelines established the following quantitative thresholds of significance for GHG emissions (MT = metric tonne, 1,000 kilograms or 2,204.6 pounds; SP = Service Population, residents + employees):

> Stationary Sources: 10,000 MT CO_2e per year

> Other than Stationary Sources: 1,100 MT CO_2e per year or 4.6 MT CO_2e per SP per year

> Plans: 6.6 MT CO_2e per SP per year

However, on March 5, 2012, the Alameda County Superior Court issued a judgment finding that the BAAQMD had failed to comply with CEQA when it adopted the thresholds of significance. The court did not determine whether the thresholds were valid on the merits, but found that the adoption of the thresholds was a project under CEQA. The court issued a writ of mandate ordering the BAAQMD to set aside the 2010 thresholds and cease dissemination of them until it had complied with CEQA. The BAAQMD is no longer recommending that the 2010 thresholds be used as a generally applicable measure of a project's significance. Lead agencies may continue to rely on the 1999 CEQA thresholds and may continue to make determinations regarding the significance of an individual project's air quality impacts based on the substantial evidence in the record for that project.

Neither Northern Sonoma County APCD nor Monterey Bay Unified APCD have applicable CEQA thresholds for greenhouse gases. Since the 1999 BAAQMD thresholds apply only to criteria pollutants, not greenhouse gases, no GHG thresholds currently apply (BAAQMD 1999, 2012b). Notwithstanding the writ of mandate, Program status would have been as follows under the 2010 Bay Area CEQA Guidelines:

> MVC activities do not meet the regulatory definition of a stationary source of air contaminants; therefore, the 10,000 metric tonne CO_2e per year stationary source GHG threshold would not apply.

> For nonstationary source land use development projects, BAAQMD's adopted "bright-line" threshold of significance differs from other proposed GHG thresholds currently under consideration in California. Under this threshold, in order to conclude that a project's GHG impacts are less than significant, a project would need to be in compliance with a "Qualified Greenhouse Gas Reduction Strategy," emit less than 1,100 metric tonnes CO_2e per year, or emit less than 4.6 metric tonnes CO_2e per year per capita service population (residents + employees). However, the Programs do not qualify as land use development projects; therefore, these GHG thresholds would not apply.

> There are no GHG thresholds for temporary construction emissions from mobile and portable sources, neither daily nor annual, whether for stationary or nonstationary source projects. Since MVC activities comprise mobile and portable sources similar to construction, no quantitative GHG significance thresholds would apply to the Programs since activities such as MVC are not specified, defined, or addressed in the guidelines.

3.6 Standards of Significance

The programmatic environmental impact report (PEIR) addresses the following qualitative standards of significance as based on CEQA Guidelines Appendix G. Would the project:

> Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment?

> Conflict with any applicable plan, policy or regulation of an agency adopted for the purpose of reducing the emissions of greenhouse gases?

For the nine Programs, determinations made with respect to significance criteria are documented in the PEIR.

3.7 Quantification Methodology

As described in Section 3.3.4, operation of onroad fleet vehicles, offroad all-terrain vehicles, watercraft, aircraft, portable equipment, and small equipment would result in emissions of GHGs in engine exhaust. Detailed lists of equipment, estimated usage, and emission calculations are provided in Attachment A. Equipment lists and annual activity schedules were provided by the nine participating Districts. Emission calculations were performed using the most recent and applicable emission factors published by CARB (2008a) and EPA (2011b, 2012b).

Table 3-8 shows alternatives applicability by percentage as selected by the nine MVC Districts: surveillance, physical control, vegetation management, biological control, chemical control, or other non-chemical control. Table 3-9 shows land uses associated with selected alternatives: residential, commercial, industrial, agricultural, and open space. As shown in Tables 3-8 and 3-9, not all alternatives or land uses are applicable in all Districts, nor are all options or activities under any applicable alternative.

3.8 Estimated Emissions

Tables 3-10 through 3-15 show estimated ongoing annual GHG emissions as CO_2e by alternative and district. Table 3-16 shows estimated combined annual emissions across all nine Districts. On the local level, the combined "grand total" of 2,600 metric tonnes CO_2e per year comprises only 0.7 percent of the 375,200 metric tonnes CO_2e per year in the utility and commercial offroad sub-sectors (see Table 3-7); this is within EPA limits of precision of -2 to +5 percent for fossil fuel combustion (EPA 2012b). On the regional level, this is less than 0.003 percent of aggregate GHG emissions from the Bay Area (see Table 3-4). At the state and national levels, these emissions are negligible: 0.0005 and 0.00004 percent, respectively (see Table 3-3). Since the combined emissions of the nine Districts would not be substantial, neither would the incremental contribution of each District.

Table 3-8 Districts' Selected Alternatives Applicability

Districts	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Non-Chemical
Alameda County MAD	12%	7%	—	1%	64%	16%
Alameda County VCSD	100%	—	—	—	—	—
Contra Costa County MVCD	16%	0.07%	0.13%	0.07%	61%	23%
Marin-Sonoma Counties MVCD	20%	5%	13%	21%	25%	15%
Napa County MAD	11%	13%	7%	2%	64%	4%
Northern Salinas Valley MAD	3%	6%	29%	7%	39%	15%
San Mateo County MVCD	11%	0%	30%	21%	13%	24%
Santa Clara County VCD	47%	3%	—	13%	37%	—
Solano County MAD	24%	—	—	0.03%	46%	30%
Nine Districts Composite	**27%**	**4%**	**9%**	**7%**	**39%**	**14%**

Sources: Nine Districts

Table 3-9 Land Uses Associated with Selected Alternatives

Districts	Residential	Commercial	Industrial	Agricultural	Open Space
Alameda County MAD	●	●	●	●	●
Alameda County VCSD	●	●			
Contra Costa County MVCD	●	●	●	●	●
Marin-Sonoma Counties MVCD	●	●	●	●	●
Napa County MAD	●	●	●	●	●
Northern Salinas Valley MAD	●	●	●	●	●
San Mateo County MVCD	●	●	●		●
Santa Clara County VCD	●	●	●	●	●
Solano County MAD	●	●	●	●	●

Sources: Nine Districts

Table 3-10 Estimated Annual GHG Emissions for Surveillance Alternative

Districts	CO_2 MT/yr	CH_4 MT/yr	N_2O MT/yr	CO_2e MT/yr
Alameda County MAD	16.3	0.0009	0.0004	16.4
Alameda County VCSD	105.4	0.0060	0.0024	106.3
Contra Costa County MVCD	21.1	0.0012	0.0005	21.3
Marin-Sonoma Counties MVCD	51.0	0.0024	0.0016	51.6
Napa County MAD	8.9	0.0004	0.0002	8.9
Northern Salinas Valley MAD	1.6	0.0001	0.0001	1.6
San Mateo County MVCD	147.6	0.0084	0.0034	148.9
Santa Clara County VCD	169.7	0.0097	0.0039	171.2
Solano County MAD	35.5	0.0016	0.0009	35.8
Nine Districts Totals	**557.2**	**0.0309**	**0.0135**	**562.0**

Sources: CARB 2008a, EPA (2011b, 2012b)

SCCVCD = Emissions for equipment use associated with rodent and wildlife trapping are reported under Surveillance.

Table 3-11 Estimated Annual GHG Emissions for Physical Control Alternative

Districts	CO_2 MT/yr	CH_4 MT/yr	N_2O MT/yr	CO_2e MT/yr
Alameda County MAD	9.4	0.0005	0.0002	9.5
Alameda County VCSD	0.0	0.0000	0.0000	0.0
Contra Costa County MVCD	0.1	0.0000	0.0000	0.1
Marin-Sonoma Counties MVCD	14.0	0.0007	0.0004	14.1
Napa County MAD	10.4	0.0005	0.0003	10.5
Northern Salinas Valley MAD	3.4	0.0002	0.0001	3.4
San Mateo County MVCD	3.3	0.0002	0.0001	3.3
Santa Clara County VCD	11.0	0.0006	0.0003	11.1
Solano County MAD	0.0	0.0000	0.0000	0.0
Nine Districts Totals	**51.5**	**0.0027**	**0.0014**	**52.0**

Sources: CARB 2008a, EPA (2011b, 2012b)

Table 3-12 Estimated Annual GHG Emissions for Vegetation Management Alternative

Districts	CO_2 MT/yr	CH_4 MT/yr	N_2O MT/yr	CO_2e MT/yr
Alameda County MAD	0.0	0.0000	0.0000	0.0
Alameda County VCSD	0.0	0.0000	0.0000	0.0
Contra Costa County MVCD	0.2	0.0000	0.0000	0.2
Marin-Sonoma Counties MVCD	34.5	0.0016	0.0011	34.8
Napa County MAD	5.6	0.0003	0.0001	5.7
Northern Salinas Valley MAD	15.3	0.0007	0.0005	15.5
San Mateo County MVCD	393.2	0.0224	0.0092	396.5
Santa Clara County VCD	0.0	0.0000	0.0000	0.0
Solano County MAD	0.0	0.0000	0.0000	0.0
Nine Districts Totals	**448.8**	**0.0251**	**0.0109**	**452.7**

Sources: CARB 2008a, EPA (2011b, 2012b)

Table 3-13 Estimated Annual GHG Emissions for Biological Control Alternative

Districts	CO_2 MT/yr	CH_4 MT/yr	N_2O MT/yr	CO_2e MT/yr
Alameda County MAD	1.0	0.0001	0.0000	1.1
Alameda County VCSD	0.0	0.0000	0.0000	0.0
Contra Costa County MVCD	0.1	0.0000	0.0000	0.1
Marin-Sonoma Counties MVCD	54.4	0.0026	0.0017	55.0
Napa County MAD	1.3	0.0001	0.0000	1.4
Northern Salinas Valley MAD	3.7	0.0002	0.0001	3.7
San Mateo County MVCD	270.4	0.0154	0.0063	272.7
Santa Clara County VCD	46.9	0.0027	0.0011	47.3
Solano County MAD	0.0	0.0000	0.0000	0.0
Nine Districts Totals	**378.0**	**0.0210**	**0.0093**	**381.3**

Sources: CARB 2008a, EPA (2011b, 2012b)

Table 3-14 Estimated Annual GHG Emissions for Chemical Control Alternative

Districts	CO_2 MT/yr	CH_4 MT/yr	N_2O MT/yr	CO_2e MT/yr
Alameda County MAD	85.4	0.0048	0.0020	86.2
Alameda County VCSD	0.0	0.0000	0.0000	0.0
Contra Costa County MVCD	81.8	0.0046	0.0019	82.4
Marin-Sonoma Counties MVCD	64.2	0.0030	0.0020	64.9
Napa County MAD	52.3	0.0027	0.0013	52.8
Northern Salinas Valley MAD	20.9	0.0009	0.0007	21.1
San Mateo County MVCD	174.2	0.0099	0.0041	175.7
Santa Clara County VCD	131.8	0.0075	0.0031	132.9
Solano County MAD	67.1	0.0031	0.0018	67.7
Nine Districts Totals	**677.7**	**0.0367**	**0.0168**	**683.7**

Sources: CARB 2008a, EPA (2011b, 2012b)

Table 3-15 Estimated Annual GHG Emissions for Other Non-Chemical Control/Trapping Alternative

Districts	CO_2 MT/yr	CH_4 MT/yr	N_2O MT/yr	CO_2e MT/yr
Alameda County MAD	21.3	0.0012	0.0005	21.4
Alameda County VCSD	0.0	0.0000	0.0000	0.0
Contra Costa County MVCD	31.4	0.0018	0.0007	31.7
Marin-Sonoma Counties MVCD	38.0	0.0018	0.0012	38.4
Napa County MAD	2.9	0.0001	0.0001	2.9
Northern Salinas Valley MAD	8.0	0.0004	0.0003	8.1
San Mateo County MVCD	305.3	0.0174	0.0071	307.8
Santa Clara County VCD	0.0	0.0000	0.0000	0.0
Solano County MAD	44.6	0.0020	0.0012	45.0
Nine Districts Totals	**451.5**	**0.0248**	**0.0111**	**455.4**

Sources: CARB 2008a, EPA (2011b, 2012b)

Notes:

ACMAD = Emissions associated with ongoing District office administration and grounds maintenance activities are reported under this alternative.

SCCVCD = Emissions for equipment use associated with rodent and wildlife trapping are reported under Surveillance.

SCMAD = Emissions referenced in the "Other Non-Chemical" category emanate from vehicles and equipment used in connection with district activities not directly related to mosquito control, such as transportation to various meetings and facilities maintenance.

Table 3-16 Estimated Combined Annual GHG Emissions Across Nine Districts

Alternatives	CO_2 MT/yr	CH_4 MT/yr	N_2O MT/yr	CO_2e MT/yr
Surveillance	557	0.0309	0.0135	562
Physical Control	52	0.0027	0.0014	52
Vegetation Management	449	0.0251	0.0109	453
Biological Control	378	0.0210	0.0093	381
Chemical Control	678	0.0367	0.0168	684
Other Non-Chemical	451	0.0248	0.0111	455
All Alternatives Totals	**2,565**	**0.1410**	**0.0630**	**2,587**

Sources: CARB 2008a, EPA (2011b, 2012b)

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Integrated Mosquito and Vector Management Programs

ATTACHMENT A

CRITERIA POLLUTANT AND GREENHOUSE GAS EMISSIONS CALCULATIONS

A-1 Ambient Air Standards

Table 2-1 Ambient Air Quality Standards

Pollutant	Averaging Time	California Standards		Federal Standards	
		ppmv	µg/m^3	ppmv	µg/m^3
Ozone (O_3)	1-hour	0.09	177	—	—
	8-hour	0.07	137	0.075	147
Nitrogen Dioxide (NO_2)	1-hour	0.18	338	0.100	188
	Annual	0.03	56	0.053	100
Sulfur Dioxide (SO_2)	1-hour	0.25	655	0.075	196
	3-hour Secondary	—	—	0.50	1,309
	24-hour	0.04	105	—	—
Carbon Monoxide (CO)	1-hour	20	22,898	35	40,071
	8-hour	9	10,304	9	10,304
	Lake Tahoe (8-hr)	6	6,869	—	—
Particulates (as PM_{10})	24-hour	—	50	—	150
	Annual	—	20	—	—
Particulates (as $PM_{2.5}$)	24-hour	—	—	—	35
	Annual Primary	—	12	—	12
	Annual Secondary	—	—	—	15
Lead (Pb)	30-day	—	1.5	—	—
	3-month (rolling)	—	—	—	0.15
Sulfates (as SO_4)	24-hour	—	25	—	—
Hydrogen Sulfide (H_2S)	1-hour	0.03	42	—	—
Vinyl Chloride (C_2H_3Cl)	24-hour	0.01	26	—	—
Visibility Reducing Particles	8-hour	Extinction coefficient of 0.23 per km; visibility of 10 miles or more (0.07 to 30 miles or more for Lake Tahoe) due to particles when relative humidity is less than 70%.		—	—

Sources: CARB 2012a, EPA 2011a

Notes:

ppmv = parts per million by volume

µg/m^3 = micrograms per cubic meter

The 1.5 µg/m^3 federal quarterly lead standard applied until 2008; 0.15 µg/m^3 rolling 3-month average thereafter

For gases, ug/m^3 calculated from ppmv based on molecular weight and standard conditions

Standard Temperature	25	deg C
Standard Molar Volume	24.465	liter/g-mole

A-2 Attainment Status

Table 2-2 Attainment Status Summary - Bay Area Region

Criteria Pollutant	State Designation	Federal Designation
Ozone (O_3) (1-hour)	Nonattainment	—
Ozone (O_3) (8-hour)	Nonattainment	Nonattainment[(1)]
Nitrogen Dioxide (NO_2) (1-hour)	Attainment	Unclassified[(2)]
Nitrogen Dioxide (NO_2) (annual)	Attainment	Attainment
Sulfur Dioxide (SO_2)	Attainment	Attainment
Carbon Monoxide (CO)	Attainment	Attainment
Resp. Particulates (as PM_{10}) (24-hour)	Nonattainment	Unclassified[(2)]
Resp. Particulates (as PM_{10}) (annual)	Nonattainment	—
Fine Particulates (as $PM_{2.5}$) (24-hour)	—	Nonattainment
Fine Particulates (as $PM_{2.5}$) (annual)	Nonattainment	Attainment
Lead (Pb)	Attainment	Attainment
Sulfates (as SO_4)	Attainment	—
Hydrogen Sulfide (H_2S)	Unclassified[(2)]	—
Vinyl Chloride (C_2H_3Cl)	n/d	—
Visibility	Unclassified[(2)]	—

Source: BAAQMD 2012a

Notes:

[(1)] The 0.08 ppmv federal 8-hour ozone standard applied until 2008; 0.075 ppmv thereafter

[(2)] At the time of designation, if the available data does not support a designation of attainment or nonattainment, the area is designated as unclassified.

n/d - no data/information available

Table 2-3 CEQA Significance Thresholds - BAAQMD (1999)

Applicability	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$
Operation, tons/year	15	CAAQS	15	40[(2)]	15	10[(2)]
Operation, pounds/year	30,000	CAAQS	30,000	80,000	30,000	20,000
Operation, pounds/day	80	CAAQS	80	—	80	—
Construction, pounds/day	80	CAAQS	80	—	80[(3)]	—

Sources: BAAQMD 1999, 2012b (see note 4), 40 CFR 51.166

Notes:

(1) No violation of CAAQS for CO (9 ppmv for 1 hour, 20 ppmv for 8 hours)

(2) Prevention of Significant Deterioration (PSD), annual only

(3) For construction projects, applies to exhaust emissions only, not fugitive dusts

(4) On March 5, 2012 the Alameda County Superior Court issued a judgment finding that the District had failed to comply with CEQA when it adopted the thresholds of significance. The court did not determine whether the thresholds were valid on the merits, but found that the adoption of the thresholds was a project under CEQA. The court issued a writ of mandate ordering the District to set aside the 2010 thresholds and cease dissemination of them until the District had complied with CEQA. The District is no longer recommending that the 2010 thresholds be used as a generally applicable measure of a project's significance. Lead Districts may continue to rely on the District's 1999 thresholds and may continue to make determinations regarding the significance of an individual project's air quality impacts based on the substantial evidence in the record for that project.

Table 2-4, 3-8 Districts' Selected Alternatives Applicability

Districts	Surveillance	Physical Control	Vegetation Management	Biological Control	Chemical Control	Other Non-Chemical
Alameda County MAD	12%	7%	—	1%	64%	16%
Alameda County VCSD	100%	—	—	—	—	—
Contra Costa County MVCD	16%	0.07%	0.13%	0.07%	61%	23%
Marin-Sonoma Counties MVCD	20%	5%	13%	21%	25%	15%
Napa County MAD	11%	13%	7%	2%	64%	4%
Northern Salinas Valley MAD	3%	6%	29%	7%	39%	15%
San Mateo County MVCD	11%	0%	30%	21%	13%	24%
Santa Clara County VCD	47%	3%	—	13%	37%	—
Solano County MAD	24%	—	—	0.03%	46%	30%
Nine Districts Composite	**27%**	**4%**	**9%**	**7%**	**39%**	**14%**

Sources: Nine Districts

Table 2-5, 3-9 Land Uses Associated with Selected Alternatives

Districts	Residential	Commercial	Industrial	Agricultural	Open Space
Alameda County MAD	■	■	■	■	■
Alameda County VCSD	■	■			
Contra Costa County MVCD	■	■	■	■	■
Marin-Sonoma Counties MVCD	■	■	■	■	■
Napa County MAD	■	■	■	■	■
Northern Salinas Valley MAD	■	■	■	■	■
San Mateo County MVCD	■	■	■		■
Santa Clara County VCD	■	■	■	■	■
Solano County MAD	■	■	■	■	■

Sources: Nine Districts

Table 2-6 Estimated Annual Criteria Emissions for Surveillance Alternative

Districts	VOC lbs/year	CO lbs/year	NO_X lbs/year	SO_X lbs/year	PM_{10} lbs/year	$PM_{2.5}$ lbs/year
Alameda County MAD	44	1,051	44	1.4	4.1	2.7
Alameda County VCSD	148	1,392	138	2.3	19.4	12.5
Contra Costa County MVCD	38	521	35	0.7	4.8	3.1
Marin-Sonoma Counties MVCD	132	2,515	298	3.5	19.5	13.9
Napa County MAD	21	718	40	0.8	2.6	1.7
Northern Salinas Valley MAD	3	57	18	0.1	0.8	0.6
San Mateo County MVCD	365	7,550	321	10.2	38.5	24.9
Santa Clara County VCD	240	2,300	226	3.7	31.3	20.3
Solano County MAD	73	1,710	225	2.6	9.0	5.9
Nine Districts Totals	**1,065**	**17,813**	**1,345**	**25.2**	**130.1**	**85.6**

Sources: CARB 2008a, EPA (1973, 1991a, 1991b, 2011b, 2011c, 2012c)

Table 2-7 Estimated Annual Criteria Emissions for Physical Control Alternative

Districts	VOC lbs/year	CO lbs/year	NO_X lbs/year	SO_X lbs/year	PM_{10} lbs/year	$PM_{2.5}$ lbs/year
Alameda County MAD	25	606	25	0.8	2.4	1.5
Alameda County VCSD	0	0	0	0.0	0.0	0.0
Contra Costa County MVCD	0	2	0	0.0	0.0	0.0
Marin-Sonoma Counties MVCD	36	689	82	1.0	5.3	3.8
Napa County MAD	25	841	47	1.0	3.1	2.0
Northern Salinas Valley MAD	7	120	38	0.2	1.7	1.3
San Mateo County MVCD	8	170	7	0.2	0.9	0.6
Santa Clara County VCD	16	149	15	0.2	2.0	1.3
Solano County MAD	0	0	0	0.0	0.0	0.0
Nine Districts Totals	**117**	**2,577**	**214**	**3.4**	**15.4**	**10.5**

Sources: CARB 2008a, EPA (1973, 1991a, 1991b, 2011b, 2011c, 2012c)

Table 2-8 Estimated Annual Criteria Emissions for Vegetation Management Alternative

Districts	VOC lbs/year	CO lbs/year	NO_X lbs/year	SO_X lbs/year	PM_{10} lbs/year	$PM_{2.5}$ lbs/year
Alameda County MAD	0	0	0	0.0	0.0	0.0
Alameda County VCSD	0	0	0	0.0	0.0	0.0
Contra Costa County MVCD	0	4	0	0.0	0.0	0.0
Marin-Sonoma Counties MVCD	89	1,700	201	2.4	13.2	9.4
Napa County MAD	14	456	26	0.5	1.7	1.1
Northern Salinas Valley MAD	30	540	173	0.7	7.4	5.9
San Mateo County MVCD	973	20,105	855	27.0	102.6	66.4
Santa Clara County VCD	0	0	0	0.0	0.0	0.0
Solano County MAD	0	0	0	0.0	0.0	0.0
Nine Districts Totals	**1,106**	**22,805**	**1,255**	**30.7**	**124.9**	**82.9**

Sources: CARB 2008a, EPA (1973, 1991a, 1991b, 2011b, 2011c, 2012c)

Table 2-9 Estimated Annual Criteria Emissions for Biological Control Alternative

Districts	VOC lbs/year	CO lbs/year	NO_X lbs/year	SO_X lbs/year	PM_{10} lbs/year	$PM_{2.5}$ lbs/year
Alameda County MAD	3	67	3	0.1	0.3	0.2
Alameda County VCSD	0	0	0	0.0	0.0	0.0
Contra Costa County MVCD	0	2	0	0.0	0.0	0.0
Marin-Sonoma Counties MVCD	141	2,683	318	3.7	20.8	14.8
Napa County MAD	3	109	6	0.1	0.4	0.3
Northern Salinas Valley MAD	7	130	42	0.2	1.8	1.4
San Mateo County MVCD	669	13,828	588	18.6	70.5	45.7
Santa Clara County VCD	66	636	62	1.0	8.7	5.6
Solano County MAD	0	2	0	0.0	0.0	0.0
Nine Districts Totals	**890**	**17,458**	**1,019**	**23.7**	**102.5**	**68.0**

Sources: CARB 2008a, EPA (1973, 1991a, 1991b, 2011b, 2011c, 2012c)

Table 2-10 Estimated Annual Criteria Emissions for Chemical Control Alternative

Districts	VOC lbs/year	CO lbs/year	NO_X lbs/year	SO_X lbs/year	PM_{10} lbs/year	$PM_{2.5}$ lbs/year
Alameda County MAD	231	5,523	229	7.4	21.6	14.0
Alameda County VCSD	0	0	0	0.0	0.0	0.0
Contra Costa County MVCD	146	2,013	136	2.9	18.6	12.1
Marin-Sonoma Counties MVCD	167	3,168	375	4.4	24.5	17.5
Napa County MAD	127	4,244	238	4.9	15.6	10.1
Northern Salinas Valley MAD	41	737	236	1.0	10.2	8.1
San Mateo County MVCD	431	8,907	379	12.0	45.4	29.4
Santa Clara County VCD	186	1,786	175	2.9	24.3	15.7
Solano County MAD	138	3,235	426	4.8	17.1	11.1
Nine Districts Totals	**1,467**	**29,613**	**2,194**	**40.2**	**177.4**	**118.0**

Sources: CARB 2008a, EPA (1973, 1991a, 1991b, 2011b, 2011c, 2012c)

Table 2-11 Estimated Annual Criteria Emissions for Other Non-Chemical Alternative

Districts	VOC lbs/year	CO lbs/year	NO_X lbs/year	SO_X lbs/year	PM_{10} lbs/year	$PM_{2.5}$ lbs/year
Alameda County MAD	58	1,374	57	1.8	5.4	3.5
Alameda County VCSD	0	0	0	0.0	0.0	0.0
Contra Costa County MVCD	56	774	52	1.1	7.2	4.6
Marin-Sonoma Counties MVCD	99	1,873	222	2.6	14.5	10.3
Napa County MAD	7	236	13	0.3	0.9	0.6
Northern Salinas Valley MAD	16	284	91	0.4	3.9	3.1
San Mateo County MVCD	755	15,609	664	21.0	79.6	51.6
Santa Clara County VCD	0	0	0	0.0	0.0	0.0
Solano County MAD	92	2,151	283	3.2	11.4	7.4
Nine Districts Totals	**1,082**	**22,300**	**1,382**	**30.4**	**122.8**	**81.1**

Sources: CARB 2008a, EPA (1973, 1991a, 1991b, 2011b, 2011c, 2012c)

Table 2-12 Estimated Combined Annual Criteria Emissions Across Nine Districts

Alternatives	VOC tons/yr	CO tons/yr	NO_X tons/yr	SO_X tons/yr	PM_{10} tons/yr	$PM_{2.5}$ tons/yr
Surveillance	0.53	8.91	0.67	0.01	0.07	0.04
Physical Control	0.06	1.29	0.11	0.00	0.01	0.01
Vegetation Management	0.55	11.40	0.63	0.02	0.06	0.04
Biological Control	0.45	8.73	0.51	0.01	0.05	0.03
Chemical Control	0.73	14.81	1.10	0.02	0.09	0.06
Other Non-Chemical	0.54	11.15	0.69	0.02	0.06	0.04
All Alternatives Totals	**2.86**	**56.28**	**3.70**	**0.08**	**0.34**	**0.22**

Sources: CARB 2008a, EPA (1973, 1991a, 1991b, 2011b, 2011c, 2012c)

Table 2-13 Estimated Peak Daily Criteria Emissions for Applicable Alternatives - Simultaneous Operations

Districts	VOC lbs/day	CO lbs/day	NO_X lbs/day	SO_X lbs/day	PM_{10} lbs/day	$PM_{2.5}$ lbs/day
Alameda County MAD	5.8	177.5	39.9	0.3	0.9	0.6
Alameda County VCSD	0.6	5.5	0.6	0.0	0.1	0.0
Contra Costa County MVCD	7.8	152.7	23.7	0.2	1.2	0.8
Marin-Sonoma Counties MVCD	15.3	394.0	44.1	0.5	2.1	1.5
Napa County MAD	6.6	255.0	31.2	0.3	0.9	0.6
Northern Salinas Valley MAD	1.7	31.1	10.0	0.0	0.4	0.3
San Mateo County MVCD	25.3	810.2	31.8	1.0	2.1	1.4
Santa Clara County VCD	2.7	26.9	3.0	0.0	0.4	0.2
Solano County MAD	9.2	283.7	43.8	0.4	1.2	0.8
Peak Total Daily Emissions	**75**	**2,137**	**228**	**3**	**9**	**6**

Sources: CARB 2008a, EPA (1973, 1991a, 1991b, 2011b, 2011c, 2012c)

Table 2-14 Estimated Highest Quarterly Criteria Emissions for Applicable Alternatives - Concurrent Operations

Districts	VOC lbs/qtr	CO lbs/qtr	NO_X lbs/qtr	SO_X lbs/qtr	PM_{10} lbs/qtr	$PM_{2.5}$ lbs/qtr
Alameda County MAD	184	5,215	197	7	15	10
Alameda County VCSD	38	355	35	1	5	3
Contra Costa County MVCD	105	1,627	105	2	13	9
Marin-Sonoma Counties MVCD	223	4,369	485	6	33	23
Napa County MAD	79	3,114	168	3	10	6
Northern Salinas Valley MAD	30	493	177	1	8	6
San Mateo County MVCD	1,329	28,290	1,125	38	140	91
Santa Clara County VCD	145	1,383	136	2	19	12
Solano County MAD	136	3,702	413	5	15	10
Nine Districts Totals	**2,268**	**48,549**	**2,841**	**65**	**258**	**170**
Average Total Daily Emissions	**35**	**747**	**44**	**1**	**4**	**3**

Sources: CARB 2008a, EPA (1973, 1991a, 1991b, 2011b, 2011c, 2012c)

Table 3-10 Estimated Annual GHG Emissions for Surveillance Alternative

Districts	CO_2 MT/yr	CH_4 MT/yr	N_2O MT/yr	CO_2e MT/yr
Alameda County MAD	16.3	0.0009	0.0004	16.4
Alameda County VCSD	105.4	0.0060	0.0024	106.3
Contra Costa County MVCD	21.1	0.0012	0.0005	21.3
Marin-Sonoma Counties MVCD	51.0	0.0024	0.0016	51.6
Napa County MAD	8.9	0.0004	0.0002	8.9
Northern Salinas Valley MAD	1.6	0.0001	0.0001	1.6
San Mateo County MVCD	147.6	0.0084	0.0034	148.9
Santa Clara County VCD	169.7	0.0097	0.0039	171.2
Solano County MAD	35.5	0.0016	0.0009	35.8
Nine Districts Totals	**557.2**	**0.0309**	**0.0135**	**562.0**

Sources: CARB 2008a, EPA (2011b, 2012b)

Table 3-11 Estimated Annual GHG Emissions for Physical Control Alternative

Districts	CO_2 MT/yr	CH_4 MT/yr	N_2O MT/yr	CO_2e MT/yr
Alameda County MAD	9.4	0.0005	0.0002	9.5
Alameda County VCSD	0.0	0.0000	0.0000	0.0
Contra Costa County MVCD	0.1	0.0000	0.0000	0.1
Marin-Sonoma Counties MVCD	14.0	0.0007	0.0004	14.1
Napa County MAD	10.4	0.0005	0.0003	10.5
Northern Salinas Valley MAD	3.4	0.0002	0.0001	3.4
San Mateo County MVCD	3.3	0.0002	0.0001	3.3
Santa Clara County VCD	11.0	0.0006	0.0003	11.1
Solano County MAD	0.0	0.0000	0.0000	0.0
Nine Districts Totals	**51.5**	**0.0027**	**0.0014**	**52.0**

Sources: CARB 2008a, EPA (2011b, 2012b)

Table 3-12 Estimated Annual GHG Emissions for Vegetation Management Alternativ

Districts	CO_2 MT/yr	CH_4 MT/yr	N_2O MT/yr	CO_2e MT/yr
Alameda County MAD	0.0	0.0000	0.0000	0.0
Alameda County VCSD	0.0	0.0000	0.0000	0.0
Contra Costa County MVCD	0.2	0.0000	0.0000	0.2
Marin-Sonoma Counties MVCD	34.5	0.0016	0.0011	34.8
Napa County MAD	5.6	0.0003	0.0001	5.7
Northern Salinas Valley MAD	15.3	0.0007	0.0005	15.5
San Mateo County MVCD	393.2	0.0224	0.0092	396.5
Santa Clara County VCD	0.0	0.0000	0.0000	0.0
Solano County MAD	0.0	0.0000	0.0000	0.0
Nine Districts Totals	**448.8**	**0.0251**	**0.0109**	**452.7**

Sources: CARB 2008a, EPA (2011b, 2012b)

Table 3-13 Estimated Annual GHG Emissions for Biological Control Alternative

Districts	CO_2 MT/yr	CH_4 MT/yr	N_2O MT/yr	CO_2e MT/yr
Alameda County MAD	1.0	0.0001	0.0000	1.1
Alameda County VCSD	0.0	0.0000	0.0000	0.0
Contra Costa County MVCD	0.1	0.0000	0.0000	0.1
Marin-Sonoma Counties MVCD	54.4	0.0026	0.0017	55.0
Napa County MAD	1.3	0.0001	0.0000	1.4
Northern Salinas Valley MAD	3.7	0.0002	0.0001	3.7
San Mateo County MVCD	270.4	0.0154	0.0063	272.7
Santa Clara County VCD	46.9	0.0027	0.0011	47.3
Solano County MAD	0.0	0.0000	0.0000	0.0
Nine Districts Totals	**378.0**	**0.0210**	**0.0093**	**381.3**

Sources: CARB 2008a, EPA (2011b, 2012b)

Table 3-14 Estimated Annual GHG Emissions for Chemical Control Alternative

Districts	CO_2 MT/yr	CH_4 MT/yr	N_2O MT/yr	CO_2e MT/yr
Alameda County MAD	85.4	0.0048	0.0020	86.2
Alameda County VCSD	0.0	0.0000	0.0000	0.0
Contra Costa County MVCD	81.8	0.0046	0.0019	82.4
Marin-Sonoma Counties MVCD	64.2	0.0030	0.0020	64.9
Napa County MAD	52.3	0.0027	0.0013	52.8
Northern Salinas Valley MAD	20.9	0.0009	0.0007	21.1
San Mateo County MVCD	174.2	0.0099	0.0041	175.7
Santa Clara County VCD	131.8	0.0075	0.0031	132.9
Solano County MAD	67.1	0.0031	0.0018	67.7
Nine Districts Totals	**677.7**	**0.0367**	**0.0168**	**683.7**

Sources: CARB 2008a, EPA (2011b, 2012b)

Table 3-15 Estimated Annual GHG Emissions for Other Non-Chemical Alternative

Districts	CO_2 MT/yr	CH_4 MT/yr	N_2O MT/yr	CO_2e MT/yr
Alameda County MAD	21.3	0.0012	0.0005	21.4
Alameda County VCSD	0.0	0.0000	0.0000	0.0
Contra Costa County MVCD	31.4	0.0018	0.0007	31.7
Marin-Sonoma Counties MVCD	38.0	0.0018	0.0012	38.4
Napa County MAD	2.9	0.0001	0.0001	2.9
Northern Salinas Valley MAD	8.0	0.0004	0.0003	8.1
San Mateo County MVCD	305.3	0.0174	0.0071	307.8
Santa Clara County VCD	0.0	0.0000	0.0000	0.0
Solano County MAD	44.6	0.0020	0.0012	45.0
Nine Districts Totals	**451.5**	**0.0248**	**0.0111**	**455.4**

Sources: CARB 2008a, EPA (2011b, 2012b)

Table 3-16 Estimated Combined Annual GHG Emissions Across Nine Districts

Alternatives	CO_2 MT/yr	CH_4 MT/yr	N_2O MT/yr	CO_2e MT/yr
Surveillance	557	0.0309	0.0135	562
Physical Control	52	0.0027	0.0014	52
Vegetation Management	449	0.0251	0.0109	453
Biological Control	378	0.0210	0.0093	381
Chemical Control	678	0.0367	0.0168	684
Other Non-Chemical	451	0.0248	0.0111	455
All Alternatives Totals	**2,565**	**0.1410**	**0.0630**	**2,587**

Sources: CARB 2008a, EPA (2011b, 2012b)

A-4 Dry Air Composition

Table 3-1 Standard Composition of Dry Air

Principal Gas	Chemical Symbol	Gas MW g/mole	Concentration ppmv	Fraction percent	Fraction MW g/mole
Nitrogen	N_2	28.014	780,805.00	78.080500	21.873471
Oxygen	O_2	31.998	209,440.00	20.944000	6.701661
Argon	Ar	39.948	9,340.00	0.934000	0.373114
Carbon Dioxide	CO_2	44.009	387.69	0.038769	0.017062
Neon	Ne	20.183	18.21	0.001821	0.000368
Helium	He	4.003	5.24	0.000524	0.000021
Methane	CH_4	16.043	1.81	0.000181	0.000029
Krypton	Kr	83.800	1.14	0.000114	0.000096
Hydrogen	H_2	2.016	0.50	0.000050	0.000001
Nitrous Oxide	N_2O	44.013	0.32	0.000032	0.000014
Xenon	Xe	31.300	0.09	0.000009	0.000003
Totals			**1,000,000.00**	**100.000**	**28.966**

Sources: UIG 2008, EPA 2012b, du Pont 1971, Jennings 1970

Notes:

MW = molecular weight, g/mole

ppmv = parts per million by volume (10^{-6})

Table 3-2 Typical GHG Contents of Common Fuels

Fuel	CO_2	CH_4	N_2O	CO_2 e	Energy	CO_2 e
	kg/mmBTU	kg/mmBTU	kg/mmBTU	lb/mmBTU	BTU/gal	lb/gal
Diesel Fuel No. 2	73.96	0.0105	0.0006	163.97	138,300	22.68
Kerosene	73.19	0.0105	0.0006	162.27	138,700	22.51
Jet Fuel	72.23	0.0105	0.0006	160.17	135,000	21.62
Motor Gasoline	71.35	0.0105	0.0006	158.23	122,600	19.40
Aviation Gasoline	69.15	0.0105	0.0006	153.38	120,200	18.44
Propane	62.22	0.0053	0.0001	137.49	91,300	12.55
Pipeline Natural Gas	53.02	0.0053	0.0001	117.20	—	—

Sources: EPA 2012b, EPA 2011b

Notes:

kg/mmBTU - kilograms per million British Thermal Units

lb/mmBTU - pounds per million British Thermal Units

BTU - the amount of energy (heat) required to raise 1 pound of liquid water 1 degree Fahrenheit from 39 to 40 °F

Table 3-3 Greenhouse Gas Emissions Inventories - Gross Basis

Summary Year	National	California	Bay Area
	MMT CO_2 e	MMT CO_2 e	MMT CO_2 e
2005	7,204	482.5	—
2006	7,159	481.9	—
2007	7,253	488.8	95.8
2008	7,048	484.7	—
2009	6,608	456.8	—
5-Year Average	**7,054**	**478.9**	—
Average Annual Variation	**2.6%**	**1.8%**	—

Sources: EPA 2012b, CARB 2011b, BAAQMD 2010b

Notes:

MMT - million metric tonnes (annual)

1 metric tonne = 1,000 kilograms or 2,204.6 pounds

2009 is most recent CARB published data; Bay Area for 2007 only

Table 3-4 Bay Area GHG Emissions by Sector

End-Use Sector	District Emissions	
	Percent	MMT CO_2 e
Industrial / Commercial	36.4%	34.9
Residential Fuel Use	7.1%	6.8
Local Electric Power Generation	8.5%	8.1
Imported Electric Power Generation	7.4%	7.1
Offroad Equipment	3.0%	2.9
Transportation	36.4%	34.9
Agriculture / Farming	1.2%	1.1
Totals	**100.0%**	**95.8**

Source: BAAQMD 2010b

Notes:

MMT - million metric tonnes (annual)

1 metric tonne = 1,000 kilograms or 2,204.6 pounds

Table 3-5 Bay Area GHG Emissions by County

County	District Emissions	
	Percent	MMT CO_2 e
Alameda	16.4%	15.7
Contra Costa	32.9%	31.5
Marin	2.8%	2.7
Napa	1.8%	1.7
San Francisco	7.4%	7.1
San Mateo	8.9%	8.5
Santa Clara	19.6%	18.8
Solano (within BAAQMD)	5.9%	5.7
Sonoma (within BAAQMD)	4.3%	4.1
Totals	**100.0%**	**95.8**

Source: BAAQMD 2010b

Notes:

MMT - million metric tonnes (annual)

1 metric tonne = 1,000 kilograms or 2,204.6 pounds

Table 3-6 Mobile Sectors GHG Emissions by County

County	Offroad	Transportation
	MT CO_2 e	MT CO_2 e
Alameda	569,000	8,351,000
Contra Costa	406,000	4,998,000
Marin	99,000	1,286,000
Napa	50,000	917,000
San Francisco	415,000	2,673,000
San Mateo	270,000	4,850,000
Santa Clara	790,000	7,859,000
Solano (within BAAQMD)	147,000	1,834,000
Sonoma (within BAAQMD)	175,000	2,103,000
Totals	**2,921,000**	**34,871,000**

Source: BAAQMD 2010b

Notes:

MT - metric tonnes (annual)

1 metric tonne = 1,000 kilograms or 2,204.6 pounds

Values rounded to nearest 1,000 tonnes

"Offroad" is offroad equipment category

Table 3-7 Offroad Sub-Sectors GHG Emissions by County

County	Utility MT CO_2 e	Commercial MT CO_2 e	Combined MT CO_2 e
Alameda	29,800	49,900	79,700
Contra Costa	20,300	26,900	47,200
Marin	7,900	12,300	20,200
Napa	2,900	4,300	7,200
San Francisco	14,200	43,900	58,100
San Mateo	14,200	27,200	41,400
Santa Clara	32,900	56,500	89,400
Solano (within BAAQMD)	3,900	6,800	10,700
Sonoma (within BAAQMD)	7,800	13,500	21,300
Totals	**133,900**	**241,300**	**375,200**

Source: BAAQMD 2010b

Notes:

MT - metric tonnes (annual)

1 metric tonne = 1,000 kilograms or 2,204.6 pounds

Values rounded to nearest 100 tonnes

"Utility" is small landscaping equipment selected for comparisons to Districts' activities

"Commercial" is light commercial equipment selected for comparisons to Districts' activities

Alameda County Mosquito Abatement District Vehicles and Equipments

Land Surveillance and Applications/Management	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
2001 6x6 Polaris ATV	500cc, liquid cooled, 4 stroke	20%				80%		100%	Gasoline
Birchmeier Flox 2.5 gal backpack sprayer	N/A					100%		100%	Zero
Birchmeier Flox 5 gal backpack sprayer	N/A					100%		100%	Zero
Brush Cutter	Kawasaki 33.33cc, 2cycle		100%					100%	50:1 gas/oil mix
Cargo Van	4.2L V6						100%	100%	Gasoline
Chainsaw	59cc, 2cycle		100%					100%	50:1 gas/oil mix
Chapin Premier Pro+ 2 gal sprayer Model 21220	N/A					100%		100%	Zero
Chapin Premier Series 3 gal polyethylene sprayer Model 2123	N/A					100%		100%	Zero
Electric Spray Rig	SHURflow electric pumps					100%		100%	Zero
Gas Spray Rig	Honda HX120, 4 stroke					100%		100%	Gasoline
Hudson X-Pert Stainless Steel 3 gal. sprayer	N/A					100%		100%	Zero
Jeep	4.0L Inline V6	10%				80%	10%	100%	Gasoline
Leaf Blower	Type #135R, 2cycle						100%	100%	50:1 gas/oil mix
Maruyama Mist Duster MD155DX	Kawasaki 40.2cc, 2cycle					100%		100%	50:1 gas/oil mix
Pickup Truck	5.4L V8	100%						100%	Gasoline
Pickup Truck	5.0L V8	40%	5%		5%	10%	40%	100%	Gasoline
Pickup Truck	4.6L V8	40%	5%		5%	10%	40%	100%	Gasoline
Pickup Truck	4.3L V6	40%	5%		5%	10%	40%	100%	Gasoline
Pickup Truck	4.0L V6	40%	5%		5%	10%	40%	100%	Gasoline
Pickup Truck	3.0L V6	40%	5%		5%	10%	40%	100%	Gasoline
SUV	4.0L V6						100%	100%	Gasoline

Water Surveillance and Applications/Management	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
2005 Hydro Traxx 6/wheel	1100cc, liquid cooled, 4cycle, 4 stroke	20%				80%		100%	Gasoline
2008 ARGO 8/Wheel Avenger	674cc, liquid cooled, 4 stroke carburetor	20%				80%		100%	Gasoline
2010/2012 ARGO 8/Wheel 750 HDI EFI	747cc, liquid cooled, 4 stroke EFI	20%				80%		100%	Gasoline
Gas Spray Rig	Honda HX120, 4 stroke					100%		100%	Gasoline
Hydro centrifugal hydraulic spray pump	N/A					100%		100%	Zero

Aerial Applications	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
1960 Hiller Soloy helicopter (Alpine) 120 gal material tank	Allison 250-C20J turboshaft, 420 shp					100%		100%	Jet A
1968 Bell 206 Jet Ranger helicopter (Alpine) 120 gal material tank	Allison 250-C20J turboshaft, 420 shp					100%		100%	Jet A
1989 Bell 206 Jet Ranger helicopter (Alpine) 120 gal material tank	Allison 250-C20J turboshaft, 420 shp					100%		100%	Jet A
Isolair 4400 bucket system (helicopter-mounted)	N/A					100%		100%	Zero
Isolair 4500 broadcaster (helicopter-mounted)	N/A					100%		100%	Zero
Isolair Air spray system model 3900 (helicopter-mounted)	N/A					100%		100%	Zero

100.00%	12%	7%	0%	1%	64%	16%	3200%	

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Sport	500	30.5	0.86	26.0	1	1	2	0	0	2	
None				0	1	0	0	0	0		
None				0	1	0	0	0	0		
2-stroke	33	2.0	0.92	1.9	1	0	0	0	1	0.5	
Onroad LD				LD	1	8	15	6	5		60
2-stroke	59	3.6	0.92	3.3	1	0	0	0	1	0.5	
None				0	1	0	0	0	0		
None				0	1	0	0	0	0		
Electric				0	6	0	10	20	1	0.15	
Utility	120	7.3	0.56	4.1	2	30	15	0	0	0.25	
None				0	1	0	0	0	0		
Onroad LD				LD	2	0	33	62	22		180
2-stroke	17	1.0	0.92	1.0	1	1	0	0	0	0.25	
2-stroke	40	2.4	0.92	2.2	1	8	5	7	0	0.75	
Onroad LD				LD	1	0	43	62	22		180
Onroad LD				LD	4	55	60	55	40		90
Onroad LD				LD	1	0	0	1	0		120
Onroad LD				LD	2	58	60	58	55		75
Onroad LD				LD	2	53	60	55	50		90
Onroad LD				LD	1	50	57	55	45		120
Onroad LD				LD	1	20	15	20	15		60

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Sport	1100	67.1	0.86	58.0	1	30	15	0	0	4	
Sport	674	41.1	0.86	35.0	1	30	15	0	0	4	
Sport	747	45.6	0.86	39.0	2	30	15	0	0	4	
Utility	120	7.3	0.56	4.1	3	30	15	0	0	4	
None				0	1	30	15	0	0	4	

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Turbine				420	1	0	1	0	0	4	
Turbine				420	1	0	1	0	0	4	
Turbine				420	1	0	1	0	0	4	
None				0	1	0	1	0	0	4	
None				0	1	0	1	0	0	4	
None				0	1	0	1	0	0	4	

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
2		4		6	
0.5		0.5		0.5	
	60		900		2040
0.5		0.5		0.5	
0.9		18		27.9	
0.5		15		22.5	
	360		22320		42120
0.25		0.25		0.25	
0.75		6		15	
	180		11160		22860
	360		21600		75600
	120		120		120
	150		9000		34650
	180		10800		39240
	120		6840		24840
	60		1200		4200

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
4		120		180	
4		120		180	
8		240		360	
12		360		540	
4		120		180	

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
4		4		4	
4		4		4	
4		4		4	
4		4		4	
4		4		4	
4		4		4	

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.14742	4.89060	0.12714	0.00655	0.00780	0.00507	12.26940	0.00069	0.00030	12.37828
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.07028	1.25727	0.00781	0.00113	0.01487	0.00967	1.94266	0.00011	0.00005	1.95989
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.17578	1.63572	0.01953	0.00196	0.02583	0.01679	3.11454	0.00018	0.00008	3.14218
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.02057	2.05585	0.01752	0.00176	0.00199	0.00129	3.54712	0.00020	0.00009	3.57859
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.03699	0.66172	0.00411	0.00060	0.00783	0.00509	1.02245	0.00006	0.00003	1.03152
0.08138	1.45578	0.00904	0.00131	0.01722	0.01119	2.24939	0.00013	0.00006	2.26935
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.32886	10.90980	0.28362	0.01462	0.01740	0.01131	27.37020	0.00155	0.00068	27.61309
0.19845	6.58350	0.17115	0.00882	0.01050	0.00683	16.51650	0.00093	0.00041	16.66307
0.22113	7.33590	0.19071	0.00983	0.01170	0.00761	18.40410	0.00104	0.00046	18.56742
0.02057	2.05585	0.01752	0.00176	0.00199	0.00129	3.54712	0.00020	0.00009	3.57859
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.00136	0.01094	2.91816	0.00515	0.03979	0.02587	541.59840	0.01497	0.01735	547.29131
0.00136	0.01094	2.91816	0.00515	0.03979	0.02587	541.59840	0.01497	0.01735	547.29131
0.00136	0.01094	2.91816	0.00515	0.03979	0.02587	541.59840	0.01497	0.01735	547.29131
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Surveillance	12%
Physical Control	7%
Vegetation Management	0%
Biological Control	1%
Chemical Control	64%
Other Non-Chemical	16%
CHECKSUM	**100%**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
0.29	9.78	0.25	0.01	0.02	0.01	24.54	0.00	0.00	24.76
0.04	0.63	0.00	0.00	0.01	0.00	0.97	0.00	0.00	0.98
0.04	0.40	0.04	0.00	0.01	0.00	66.15	0.00	0.00	66.71
0.09	0.82	0.01	0.00	0.01	0.01	1.56	0.00	0.00	1.57
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.01	1.03	0.01	0.00	0.00	0.00	1.77	0.00	0.00	1.79
0.25	2.38	0.24	0.00	0.03	0.02	396.93	0.02	0.01	400.26
0.01	0.17	0.00	0.00	0.00	0.00	0.26	0.00	0.00	0.26
0.06	1.09	0.01	0.00	0.01	0.01	1.69	0.00	0.00	1.70
0.13	1.19	0.12	0.00	0.02	0.01	198.46	0.01	0.00	200.13
0.25	2.38	0.24	0.00	0.03	0.02	396.93	0.02	0.01	400.26
0.08	0.79	0.08	0.00	0.01	0.01	132.31	0.01	0.00	133.42
0.11	0.99	0.10	0.00	0.01	0.01	165.39	0.01	0.00	166.77
0.13	1.19	0.12	0.00	0.02	0.01	198.46	0.01	0.00	200.13
0.08	0.79	0.08	0.00	0.01	0.01	132.31	0.01	0.00	133.42
0.04	0.40	0.04	0.00	0.01	0.00	66.15	0.00	0.00	66.71
1.62	**24.01**	**1.33**	**0.03**	**0.20**	**0.13**	**1783.87**	**0.10**	**0.04**	**1798.85**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
1.32	43.64	1.13	0.06	0.07	0.05	109.48	0.01	0.00	110.45
0.79	26.33	0.68	0.04	0.04	0.03	66.07	0.00	0.00	66.65
1.77	58.69	1.53	0.08	0.09	0.06	147.23	0.01	0.00	148.54
0.25	24.67	0.21	0.02	0.02	0.02	42.57	0.00	0.00	42.94
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4.13	**153.33**	**3.55**	**0.19**	**0.23**	**0.15**	**365.34**	**0.02**	**0.01**	**368.59**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
0.01	0.04	11.67	0.02	0.16	0.10	2166.39	0.06	0.07	2189.17
0.01	0.04	11.67	0.02	0.16	0.10	2166.39	0.06	0.07	2189.17
0.01	0.04	11.67	0.02	0.16	0.10	2166.39	0.06	0.07	2189.17
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.02	**0.13**	**35.02**	**0.06**	**0.48**	**0.31**	**6499.18**	**0.18**	**0.21**	**6567.50**
5.76	**177.47**	**39.90**	**0.29**	**0.90**	**0.59**	**8648.40**	**0.30**	**0.26**	**8734.93**

0.70	21.63	4.86	0.04	0.11	0.07	1054.02	0.04	0.03	1064.57
0.40	12.48	2.81	0.02	0.06	0.04	608.09	0.02	0.02	614.17
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.04	1.39	0.31	0.00	0.01	0.00	67.57	0.00	0.00	68.24
3.69	113.69	25.56	0.19	0.58	0.38	5540.38	0.19	0.17	5595.82
0.92	28.28	6.36	0.05	0.14	0.09	1378.34	0.05	0.04	1392.13
5.76	**177.47**	**39.90**	**0.29**	**0.90**	**0.59**	**8648.40**	**0.30**	**0.26**	**8734.93**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
0.6	19.6	0.5	0.0	0.0	0.0	49.1	0.0	0.0	49.5
0.0	0.6	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0
0.6	5.9	0.6	0.0	0.1	0.1	992.3	0.1	0.0	1000.6
0.1	0.8	0.0	0.0	0.0	0.0	1.6	0.0	0.0	1.6
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.3	30.8	0.3	0.0	0.0	0.0	53.2	0.0	0.0	53.7
15.7	147.4	14.6	0.2	2.1	1.3	24609.4	1.4	0.6	24815.8
0.0	0.2	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.3
0.5	8.7	0.1	0.0	0.1	0.1	13.5	0.0	0.0	13.6
7.8	73.7	7.3	0.1	1.0	0.7	12304.7	0.7	0.3	12407.9
15.2	142.6	14.1	0.2	2.0	1.3	23815.6	1.4	0.6	24015.3
0.1	0.8	0.1	0.0	0.0	0.0	132.3	0.0	0.0	133.4
6.3	59.4	5.9	0.1	0.8	0.5	9923.1	0.6	0.2	10006.4
7.6	71.3	7.1	0.1	1.0	0.6	11907.8	0.7	0.3	12007.7
4.8	45.2	4.5	0.1	0.6	0.4	7541.6	0.4	0.2	7604.8
0.8	7.9	0.8	0.0	0.1	0.1	1323.1	0.1	0.0	1334.2
60.47	**615.05**	**55.81**	**0.96**	**7.90**	**5.11**	**92668.46**	**5.30**	**2.15**	**93445.77**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
39.46	1309.18	34.03	1.75	2.09	1.36	3284.42	0.19	0.08	3313.57
23.81	790.02	20.54	1.06	1.26	0.82	1981.98	0.11	0.05	1999.57
53.07	1760.62	45.77	2.36	2.81	1.83	4416.98	0.25	0.11	4456.18
7.40	740.11	6.31	0.63	0.72	0.47	1276.96	0.07	0.03	1288.29
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
123.75	**4599.92**	**106.65**	**5.81**	**6.87**	**4.47**	**10960.35**	**0.62**	**0.27**	**11057.61**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
0.01	0.04	11.67	0.02	0.16	0.10	2166.39	0.06	0.07	2189.17
0.01	0.04	11.67	0.02	0.16	0.10	2166.39	0.06	0.07	2189.17
0.01	0.04	11.67	0.02	0.16	0.10	2166.39	0.06	0.07	2189.17
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.02	**0.13**	**35.02**	**0.06**	**0.48**	**0.31**	**6499.18**	**0.18**	**0.21**	**6567.50**

184.24	**5215.10**	**197.48**	**6.83**	**15.25**	**9.88**	**110127.99**	**6.10**	**2.63**	**111070.88**

22.45	635.59	24.07	0.83	1.86	1.20	13421.85	0.74	0.32	13536.76
12.95	366.69	13.88	0.48	1.07	0.69	7743.37	0.43	0.18	7809.67
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.44	40.74	1.54	0.05	0.12	0.08	860.37	0.05	0.02	867.74
118.03	3340.92	126.51	4.37	9.77	6.33	70550.75	3.91	1.68	71154.78
29.36	831.16	31.47	1.09	2.43	1.58	17551.65	0.97	0.42	17701.92
184.24	**5215.10**	**197.48**	**6.83**	**15.25**	**9.88**	**110127.99**	**6.10**	**2.63**	**111070.88**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
0.9	29.3	0.8	0.0	0.0	0.0	73.6	0.0	0.0	74.3
0.0	0.6	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0
1.4	13.5	1.3	0.0	0.2	0.1	2249.2	0.1	0.1	2268.1
0.1	0.8	0.0	0.0	0.0	0.0	1.6	0.0	0.0	1.6
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.5	46.3	0.4	0.0	0.0	0.0	79.8	0.0	0.0	80.5
29.6	278.1	27.6	0.5	3.9	2.5	46440.3	2.7	1.1	46829.9
0.0	0.2	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.3
1.2	21.8	0.1	0.0	0.3	0.2	33.7	0.0	0.0	34.0
16.1	151.0	15.0	0.2	2.1	1.4	25204.8	1.4	0.6	25416.2
53.1	499.2	49.5	0.8	6.9	4.5	83354.4	4.8	1.9	84053.6
0.1	0.8	0.1	0.0	0.0	0.0	132.3	0.0	0.0	133.4
24.3	228.8	22.7	0.4	3.2	2.1	38204.1	2.2	0.9	38524.6
27.6	259.1	25.7	0.4	3.6	2.3	43264.9	2.5	1.0	43627.8
17.4	164.0	16.3	0.3	2.3	1.5	27387.9	1.6	0.6	27617.6
2.9	27.7	2.8	0.0	0.4	0.2	4630.8	0.3	0.1	4669.6
175.23	**1721.34**	**162.18**	**2.73**	**22.94**	**14.83**	**271058.83**	**15.52**	**6.28**	**273332.41**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
59.19	1963.76	51.05	2.63	3.13	2.04	4926.64	0.28	0.12	4970.36
35.72	1185.03	30.81	1.59	1.89	1.23	2972.97	0.17	0.07	2999.35
79.61	2640.92	68.66	3.54	4.21	2.74	6625.48	0.37	0.16	6684.27
11.11	1110.16	9.46	0.95	1.07	0.70	1915.44	0.11	0.05	1932.44
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
185.63	**6899.88**	**159.97**	**8.71**	**10.31**	**6.70**	**16440.52**	**0.93**	**0.41**	**16586.42**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
0.01	0.04	11.67	0.02	0.16	0.10	2166.39	0.06	0.07	2189.17
0.01	0.04	11.67	0.02	0.16	0.10	2166.39	0.06	0.07	2189.17
0.01	0.04	11.67	0.02	0.16	0.10	2166.39	0.06	0.07	2189.17
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.02	**0.13**	**35.02**	**0.06**	**0.48**	**0.31**	**6499.18**	**0.18**	**0.21**	**6567.50**

360.87	**8621.35**	**357.17**	**11.50**	**33.72**	**21.84**	**293998.53**	**16.63**	**6.90**	**296486.32**

43.98	1050.73	43.53	1.40	4.11	2.66	35831.07	2.03	0.84	36134.27
25.37	606.19	25.11	0.81	2.37	1.54	20671.77	1.17	0.49	20846.69
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.82	67.35	2.79	0.09	0.26	0.17	2296.86	0.13	0.05	2316.30
231.18	5523.05	228.81	7.37	21.60	13.99	188342.81	10.65	4.42	189936.55
57.51	1374.03	56.92	1.83	5.37	3.48	46856.02	2.65	1.10	47252.51
360.87	**8621.35**	**357.17**	**11.50**	**33.72**	**21.84**	**293998.53**	**16.63**	**6.90**	**296486.32**

Alameda County Vector Control Services District Vehicles and Equipments

Land Surveillance and Applications/Management	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
GMC Pickup Truck (3)	V-8	100%						100%	Gasoline
Ford Pickup Truck (1)	V-8	100%						100%	Gasoline
Dodge Pickup Truck (8)	V-8	100%						100%	Gasoline
Nissan Pickup Truck (2)	V-8	100%						100%	Gasoline

Water Surveillance and Applications/Management	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel

Aerial Applications	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel

	100.00%	100%	0%	0%	0%	0%	0%	400%

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Onroad LD				LD	3	62	64	63	62		60
Onroad LD				LD	1	62	64	63	62		60
Onroad LD				LD	8	62	64	63	62		60
Onroad LD				LD	2	62	64	63	62		60

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
	180		11520		45180
	60		3840		15060
	480		30720		120480
	120		7680		30120

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit

Surveillance	100%
Physical Control	0%
Vegetation Management	0%
Biological Control	0%
Chemical Control	0%
Other Non-Chemical	0%
CHECKSUM	**100%**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
0.13	1.19	0.12	0.00	0.02	0.01	198.46	0.01	0.00	200.13
0.04	0.40	0.04	0.00	0.01	0.00	66.15	0.00	0.00	66.71
0.34	3.17	0.31	0.01	0.04	0.03	529.23	0.03	0.01	533.67
0.08	0.79	0.08	0.00	0.01	0.01	132.31	0.01	0.00	133.42
0.59	**5.55**	**0.55**	**0.01**	**0.08**	**0.05**	**926.16**	**0.05**	**0.02**	**933.93**
VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day

0.59	**5.55**	**0.55**	**0.01**	**0.08**	**0.05**	**926.16**	**0.05**	**0.02**	**933.93**

0.59	5.55	0.55	0.01	0.08	0.05	926.16	0.05	0.02	933.93
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.59	**5.55**	**0.55**	**0.01**	**0.08**	**0.05**	**926.16**	**0.05**	**0.02**	**933.93**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
8.1	76.1	7.5	0.1	1.1	0.7	12701.6	0.7	0.3	12808.2
2.7	25.4	2.5	0.0	0.4	0.2	4233.9	0.2	0.1	4269.4
21.6	202.9	20.1	0.3	2.8	1.8	33871.0	1.9	0.8	34155.1
5.4	50.7	5.0	0.1	0.7	0.5	8467.8	0.5	0.2	8538.8
37.75	**355.01**	**35.20**	**0.57**	**4.94**	**3.19**	**59274.27**	**3.39**	**1.37**	**59771.43**
VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
37.75	**355.01**	**35.20**	**0.57**	**4.94**	**3.19**	**59274.27**	**3.39**	**1.37**	**59771.43**

37.75	355.01	35.20	0.57	4.94	3.19	59274.27	3.39	1.37	59771.43
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
37.75	**355.01**	**35.20**	**0.57**	**4.94**	**3.19**	**59274.27**	**3.39**	**1.37**	**59771.43**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
31.7	298.3	29.6	0.5	4.1	2.7	49814.2	2.9	1.2	50232.0
10.6	99.4	9.9	0.2	1.4	0.9	16604.7	1.0	0.4	16744.0
84.6	795.6	78.9	1.3	11.1	7.2	132837.9	7.6	3.1	133952.0
21.2	198.9	19.7	0.3	2.8	1.8	33209.5	1.9	0.8	33488.0
148.07	**1392.29**	**138.07**	**2.25**	**19.37**	**12.52**	**232466.29**	**13.31**	**5.39**	**234416.09**
VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr

148.07	**1392.29**	**138.07**	**2.25**	**19.37**	**12.52**	**232466.29**	**13.31**	**5.39**	**234416.09**

148.07	1392.29	138.07	2.25	19.37	12.52	232466.29	13.31	5.39	234416.09
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
148.07	**1392.29**	**138.07**	**2.25**	**19.37**	**12.52**	**232466.29**	**13.31**	**5.39**	**234416.09**

Contra Costa County Mosquito and Vector Control District Vehicles and Equipments

Land Surveillance and Applications/Management	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
A-1 Mist Blower	Honda GX160					100%		100%	Gasoline
Chevy Pickup Truck	4.8 L	68%	1%	2%	1%	28%		100%	Gasoline
Chevy Pickup Truck	5.3 L	68%	1%	2%	1%	28%		100%	Gasoline
Chevy Pickup Truck	5.7 L						100%	100%	Gasoline
Chevy Pickup Truck	6.0 L						100%	100%	Gasoline
Chevy Pickup Truck	7.4 L						100%	100%	Gasoline
Chevy Sedan	4.3 L						100%	100%	Gasoline
Chevy Van	4.3 L						100%	100%	Gasoline
Clarke-Cougar ULV	Briggs and Stratton					100%		100%	Gasoline
Colt-T ULV	Tecumseh TCII					100%		100%	50:1 gas/oil mix
Hand Sprayer – LECO ULV Model 800	Briggs and Stratton					100%		100%	Gasoline
Hand Sprayer – Mozzie ULV Model 250	Electric					100%		100%	Zero
LECO P-1 ULV	Robin Eco25					100%		100%	50:1 gas/oil mix
Maruyama Mist Duster MD155DX	Kawasaki					100%		100%	50:1 gas/oil mix
MicroGen ED2-20	Briggs and Stratton					100%		100%	Gasoline
Stihl SR420	Stihl					100%		100%	50:1 gas/oil mix
Storm Mister	Honda GX390					100%		100%	Gasoline
Toyota SUV	2.4 L						100%	100%	Gasoline
Transfer Tank Rears 200SS	Honda GX160						100%	100%	Gasoline

Water Surveillance and Applications/Management	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
Argo ATV	Kawasaki 26 hp	25%				75%		100%	Gasoline
Gregor Boat	Johnson 15 hp 4 stroke	100%						100%	Gasoline
Honda ATV	Honda 475cc 4 stroke	80%				20%		100%	Gasoline
Kvichak Conquest Boat	Johnson 115 hp 2 stroke	50%				50%		100%	50:1 gas/oil mix
Polaris ATV	Polaris 300cc 4 stroke	80%				20%		100%	Gasoline

Aerial Applications	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
1960 Hiller Soloy helicopter	Allison 250-C20J turboshaft 420 shp					100%		100%	Jet A
1968 Bell 206 Jet Ranger helicopter	Allison 250-C20J turboshaft 420 shp					100%		100%	Jet A
1982 Eagle DW-1	Lycoming 300hp (IO-540-M1B5D)					100%		100%	Jet A
1987 Air Tractor AT-501	Pratt & Whitney 600 shp					100%		100%	Jet A
1989 Bell 206 Jet Ranger helicopter	Allison 250-C20J turboshaft 420 shp					100%		100%	Jet A
1992 Air Tractor AT-502 Turbine (PT6A series turboprop)	507 kW (680shp) Pratt & Whitney Canada					100%		100%	Jet A
		100.00%	16%	0%	0%	0%	61%	23%	3000%

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Utility	160	9.8	0.56	5.5	1		1	8		1.2	
Onroad LD				LD	15	30	65	65	30		60
Onroad LD				LD	3	15	30	30	15		45
Onroad LD				LD	6	0	5	5	0		15
Onroad LD				LD	6	0	5	5	0		15
Onroad LD				LD	7	0	65	65	0		83
Onroad LD				LD	1	12	12	12	12		15
Onroad LD				LD	1	2	0	0	2		30
Utility	146	8.9	0.56	5.0	1			9		2.5	
2-stroke	49	3.0	0.92	2.8	1		6	8		0.75	
Utility	146	8.9	0.56	5.0	1		1	7		2	
Electric				0	2		1	7		2	
2-stroke	25	1.5	0.92	1.4	2		1			1	
2-stroke	40	2.4	0.92	2.2	3	4	22	15		1.75	
Utility	146	8.9	0.56	5.0	1		1			0.5	
2-stroke	59	3.6	0.92	3.3	1		1			0.5	
Utility	390	23.8	0.56	13.0	1		1			0.5	
Onroad LD				LD	2	8	8	8	8		30
Utility	160	9.8	0.56	5.5	1		1	1		0.5	

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Sport	495	30.2	0.86	26.0	7	2	7.5	3.5		2	
Sport	285	17.4	0.86	15.0	1		1			0.5	
Sport	475	29.0	0.86	25.0	1		8	10		1	
2-stroke	2049	125.0	0.92	115.0	1		1			0.5	
Sport	300	18.3	0.86	16.0	2		8	10		1	

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Turbine				420	1		1			1	
Turbine				420	1		1			1	
Turbine				300	1		1			1	
Turbine				600	1		1			1	
Turbine				420	1		1			1	
Turbine				680	1		1			1	

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
1.2		9.6		10.8	
	900		58500		171000
	135		4050		12150
	90		450		900
	90		450		900
	577.5		37537.5		75075
	15		180		720
	30		60		120
2.5		22.5		22.5	
0.75		6		10.5	
2		14		16	
4		28		32	
2		2		2	
5.25		115.5		215.25	
0.5		0.5		0.5	
0.5		0.5		0.5	
0.5		0.5		0.5	
	60		480		1920
0.5		0.5		1	

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
14		105		182	
0.5		0.5		0.5	
1		10		18	
0.5		0.5		0.5	
2		20		36	

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
1		1		1	
1		1		1	
1		1		1	
1		1		1	
1		1		1	
1		1		1	

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.02759	2.75785	0.02350	0.00236	0.00267	0.00173	4.75833	0.00027	0.00012	4.80055
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.02508	2.50713	0.02136	0.00215	0.00243	0.00158	4.32575	0.00024	0.00011	4.36414
0.10357	1.85281	0.01151	0.00167	0.02191	0.01424	2.86286	0.00016	0.00007	2.88827
0.02508	2.50713	0.02136	0.00215	0.00243	0.00158	4.32575	0.00024	0.00011	4.36414
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.05179	0.92641	0.00575	0.00083	0.01096	0.00712	1.43143	0.00008	0.00004	1.44413
0.08138	1.45578	0.00904	0.00131	0.01722	0.01119	2.24939	0.00013	0.00006	2.26935
0.02508	2.50713	0.02136	0.00215	0.00243	0.00158	4.32575	0.00024	0.00011	4.36414
0.17578	1.63572	0.01953	0.00196	0.02583	0.01679	3.11454	0.00018	0.00008	3.14218
0.12285	4.07550	0.10595	0.00546	0.00650	0.00423	10.22450	0.00058	0.00025	10.31523
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.02759	2.75785	0.02350	0.00236	0.00267	0.00173	4.75833	0.00027	0.00012	4.80055

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.14742	4.89060	0.12714	0.00655	0.00780	0.00507	12.26940	0.00069	0.00030	12.37828
0.08505	2.82150	0.07335	0.00378	0.00450	0.00293	7.07850	0.00040	0.00018	7.14132
0.14175	4.70250	0.12225	0.00630	0.00750	0.00488	11.79750	0.00067	0.00029	11.90219
6.12563	57.00237	0.68063	0.06845	0.90004	0.58503	90.44750	0.00512	0.00224	91.25014
0.09072	3.00960	0.07824	0.00403	0.00480	0.00312	7.55040	0.00043	0.00019	7.61740

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.00136	0.01094	2.91816	0.00515	0.03979	0.02587	541.59840	0.01497	0.01735	547.29131
0.00136	0.01094	2.91816	0.00515	0.03979	0.02587	541.59840	0.01497	0.01735	547.29131
0.00097	0.00782	2.08440	0.00368	0.02842	0.01848	386.85600	0.01069	0.01239	390.92236
0.00194	0.01563	4.16880	0.00736	0.05685	0.03695	773.71200	0.02138	0.02479	781.84472
0.00136	0.01094	2.91816	0.00515	0.03979	0.02587	541.59840	0.01497	0.01735	547.29131
0.00220	0.01772	4.72464	0.00835	0.06443	0.04188	876.87360	0.02424	0.02809	886.09069

Surveillance	16%
Physical Control	0%
Vegetation Management	0%
Biological Control	0%
Chemical Control	61%
Other Non-Chemical	23%
CHECKSUM	**100%**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
0.03	3.31	0.03	0.00	0.00	0.00	5.71	0.00	0.00	5.76
0.63	5.94	0.59	0.01	0.08	0.05	992.31	0.06	0.02	1000.64
0.09	0.89	0.09	0.00	0.01	0.01	148.85	0.01	0.00	150.10
0.06	0.59	0.06	0.00	0.01	0.01	99.23	0.01	0.00	100.06
0.06	0.59	0.06	0.00	0.01	0.01	99.23	0.01	0.00	100.06
0.41	3.81	0.38	0.01	0.05	0.03	636.74	0.04	0.01	642.08
0.01	0.10	0.01	0.00	0.00	0.00	16.54	0.00	0.00	16.68
0.02	0.20	0.02	0.00	0.00	0.00	33.08	0.00	0.00	33.35
0.06	6.27	0.05	0.01	0.01	0.00	10.81	0.00	0.00	10.91
0.08	1.39	0.01	0.00	0.02	0.01	2.15	0.00	0.00	2.17
0.05	5.01	0.04	0.00	0.00	0.00	8.65	0.00	0.00	8.73
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.10	1.85	0.01	0.00	0.02	0.01	2.86	0.00	0.00	2.89
0.43	7.64	0.05	0.01	0.09	0.06	11.81	0.00	0.00	11.91
0.01	1.25	0.01	0.00	0.00	0.00	2.16	0.00	0.00	2.18
0.09	0.82	0.01	0.00	0.01	0.01	1.56	0.00	0.00	1.57
0.06	2.04	0.05	0.00	0.00	0.00	5.11	0.00	0.00	5.16
0.04	0.40	0.04	0.00	0.01	0.00	66.15	0.00	0.00	66.71
0.01	1.38	0.01	0.00	0.00	0.00	2.38	0.00	0.00	2.40
2.26	**43.50**	**1.52**	**0.05**	**0.34**	**0.22**	**2145.34**	**0.12**	**0.05**	**2163.36**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
2.06	68.47	1.78	0.09	0.11	0.07	171.77	0.01	0.00	173.30
0.04	1.41	0.04	0.00	0.00	0.00	3.54	0.00	0.00	3.57
0.14	4.70	0.12	0.01	0.01	0.00	11.80	0.00	0.00	11.90
3.06	28.50	0.34	0.03	0.45	0.29	45.22	0.00	0.00	45.63
0.18	6.02	0.16	0.01	0.01	0.01	15.10	0.00	0.00	15.23
5.49	**109.10**	**2.44**	**0.14**	**0.58**	**0.38**	**247.43**	**0.01**	**0.01**	**249.63**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
0.00	0.01	2.92	0.01	0.04	0.03	541.60	0.01	0.02	547.29
0.00	0.01	2.92	0.01	0.04	0.03	541.60	0.01	0.02	547.29
0.00	0.01	2.08	0.00	0.03	0.02	386.86	0.01	0.01	390.92
0.00	0.02	4.17	0.01	0.06	0.04	773.71	0.02	0.02	781.84
0.00	0.01	2.92	0.01	0.04	0.03	541.60	0.01	0.02	547.29
0.00	0.02	4.72	0.01	0.06	0.04	876.87	0.02	0.03	886.09
0.01	**0.07**	**19.73**	**0.03**	**0.27**	**0.17**	**3662.24**	**0.10**	**0.12**	**3700.73**

7.76	**152.67**	**23.69**	**0.23**	**1.18**	**0.77**	**6055.01**	**0.24**	**0.17**	**6113.72**

1.22	23.97	3.72	0.04	0.19	0.12	950.64	0.04	0.03	959.85
0.01	0.10	0.02	0.00	0.00	0.00	4.04	0.00	0.00	4.08
0.01	0.20	0.03	0.00	0.00	0.00	8.07	0.00	0.00	8.15
0.01	0.10	0.02	0.00	0.00	0.00	4.04	0.00	0.00	4.08
4.71	92.67	14.38	0.14	0.72	0.47	3675.39	0.14	0.11	3711.03
1.81	35.62	5.53	0.05	0.28	0.18	1412.83	0.06	0.04	1426.53
7.76	**152.67**	**23.69**	**0.23**	**1.18**	**0.77**	**6055.01**	**0.24**	**0.17**	**6113.72**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
0.3	26.5	0.2	0.0	0.0	0.0	45.7	0.0	0.0	46.1
41.1	386.3	38.3	0.6	5.4	3.5	64500.5	3.7	1.5	65041.5
2.8	26.7	2.7	0.0	0.4	0.2	4465.4	0.3	0.1	4502.9
0.3	3.0	0.3	0.0	0.0	0.0	496.2	0.0	0.0	500.3
0.3	3.0	0.3	0.0	0.0	0.0	496.2	0.0	0.0	500.3
26.4	247.9	24.6	0.4	3.4	2.2	41387.8	2.4	1.0	41734.9
0.1	1.2	0.1	0.0	0.0	0.0	198.5	0.0	0.0	200.1
0.0	0.4	0.0	0.0	0.0	0.0	66.2	0.0	0.0	66.7
0.6	56.4	0.5	0.0	0.1	0.0	97.3	0.0	0.0	98.2
0.6	11.1	0.1	0.0	0.1	0.1	17.2	0.0	0.0	17.3
0.4	35.1	0.3	0.0	0.0	0.0	60.6	0.0	0.0	61.1
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	1.9	0.0	0.0	0.0	0.0	2.9	0.0	0.0	2.9
9.4	168.1	1.0	0.2	2.0	1.3	259.8	0.0	0.0	262.1
0.0	1.3	0.0	0.0	0.0	0.0	2.2	0.0	0.0	2.2
0.1	0.8	0.0	0.0	0.0	0.0	1.6	0.0	0.0	1.6
0.1	2.0	0.1	0.0	0.0	0.0	5.1	0.0	0.0	5.2
0.3	3.2	0.3	0.0	0.0	0.0	529.2	0.0	0.0	533.7
0.0	1.4	0.0	0.0	0.0	0.0	2.4	0.0	0.0	2.4
82.91	**976.22**	**68.82**	**1.36**	**11.62**	**7.52**	**112634.47**	**6.45**	**2.61**	**113579.43**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
15.5	513.5	13.3	0.7	0.8	0.5	1288.3	0.1	0.0	1299.7
0.0	1.4	0.0	0.0	0.0	0.0	3.5	0.0	0.0	3.6
1.4	47.0	1.2	0.1	0.1	0.0	118.0	0.0	0.0	119.0
3.1	28.5	0.3	0.0	0.5	0.3	45.2	0.0	0.0	45.6
1.8	60.2	1.6	0.1	0.1	0.1	151.0	0.0	0.0	152.3
21.82	**650.64**	**16.51**	**0.87**	**1.44**	**0.94**	**1606.03**	**0.09**	**0.04**	**1620.29**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
0.0	0.0	2.9	0.0	0.0	0.0	541.6	0.0	0.0	547.3
0.0	0.0	2.9	0.0	0.0	0.0	541.6	0.0	0.0	547.3
0.0	0.0	2.1	0.0	0.0	0.0	386.9	0.0	0.0	390.9
0.0	0.0	4.2	0.0	0.1	0.0	773.7	0.0	0.0	781.8
0.0	0.0	2.9	0.0	0.0	0.0	541.6	0.0	0.0	547.3
0.0	0.0	4.7	0.0	0.1	0.0	876.9	0.0	0.0	886.1
0.01	**0.07**	**19.73**	**0.03**	**0.27**	**0.17**	**3662.24**	**0.10**	**0.12**	**3700.73**

104.73	**1626.93**	**105.06**	**2.26**	**13.33**	**8.63**	**117902.74**	**6.64**	**2.77**	**118900.44**

16.44	255.43	16.50	0.35	2.09	1.36	18510.73	1.04	0.43	18667.37
0.07	1.08	0.07	0.00	0.01	0.01	78.60	0.00	0.00	79.27
0.14	2.17	0.14	0.00	0.02	0.01	157.20	0.01	0.00	158.53
0.07	1.08	0.07	0.00	0.01	0.01	78.60	0.00	0.00	79.27
63.57	987.55	63.77	1.37	8.09	5.24	71566.96	4.03	1.68	72172.57
24.44	379.62	24.51	0.53	3.11	2.01	27510.64	1.55	0.65	27743.44
104.73	**1626.93**	**105.06**	**2.26**	**13.33**	**8.63**	**117902.74**	**6.64**	**2.77**	**118900.44**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
0.3	29.8	0.3	0.0	0.0	0.0	51.4	0.0	0.0	51.8
120.1	1129.2	112.0	1.8	15.7	10.2	188539.8	10.8	4.4	190121.2
8.5	80.2	8.0	0.1	1.1	0.7	13396.3	0.8	0.3	13508.6
0.6	5.9	0.6	0.0	0.1	0.1	992.3	0.1	0.0	1000.6
0.6	5.9	0.6	0.0	0.1	0.1	992.3	0.1	0.0	1000.6
52.7	495.8	49.2	0.8	6.9	4.5	82775.6	4.7	1.9	83469.9
0.5	4.8	0.5	0.0	0.1	0.0	793.9	0.0	0.0	800.5
0.1	0.8	0.1	0.0	0.0	0.0	132.3	0.0	0.0	133.4
0.6	56.4	0.5	0.0	0.1	0.0	97.3	0.0	0.0	98.2
1.1	19.5	0.1	0.0	0.2	0.1	30.1	0.0	0.0	30.3
0.4	40.1	0.3	0.0	0.0	0.0	69.2	0.0	0.0	69.8
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	1.9	0.0	0.0	0.0	0.0	2.9	0.0	0.0	2.9
17.5	313.4	1.9	0.3	3.7	2.4	484.2	0.0	0.0	488.5
0.0	1.3	0.0	0.0	0.0	0.0	2.2	0.0	0.0	2.2
0.1	0.8	0.0	0.0	0.0	0.0	1.6	0.0	0.0	1.6
0.1	2.0	0.1	0.0	0.0	0.0	5.1	0.0	0.0	5.2
1.3	12.7	1.3	0.0	0.2	0.1	2116.9	0.1	0.0	2134.7
0.0	2.8	0.0	0.0	0.0	0.0	4.8	0.0	0.0	4.8
204.71	**2203.15**	**175.33**	**3.23**	**28.24**	**18.27**	**290488.02**	**16.63**	**6.73**	**292924.84**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
26.8	890.1	23.1	1.2	1.4	0.9	2233.0	0.1	0.1	2252.8
0.0	1.4	0.0	0.0	0.0	0.0	3.5	0.0	0.0	3.6
2.6	84.6	2.2	0.1	0.1	0.1	212.4	0.0	0.0	214.2
3.1	28.5	0.3	0.0	0.5	0.3	45.2	0.0	0.0	45.6
3.3	108.3	2.8	0.1	0.2	0.1	271.8	0.0	0.0	274.2
35.75	**1112.99**	**28.53**	**1.49**	**2.18**	**1.42**	**2765.96**	**0.16**	**0.07**	**2790.51**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
0.0	0.0	2.9	0.0	0.0	0.0	541.6	0.0	0.0	547.3
0.0	0.0	2.9	0.0	0.0	0.0	541.6	0.0	0.0	547.3
0.0	0.0	2.1	0.0	0.0	0.0	386.9	0.0	0.0	390.9
0.0	0.0	4.2	0.0	0.1	0.0	773.7	0.0	0.0	781.8
0.0	0.0	2.9	0.0	0.0	0.0	541.6	0.0	0.0	547.3
0.0	0.0	4.7	0.0	0.1	0.0	876.9	0.0	0.0	886.1
0.01	**0.07**	**19.73**	**0.03**	**0.27**	**0.17**	**3662.24**	**0.10**	**0.12**	**3700.73**

240.47	**3316.22**	**223.60**	**4.75**	**30.69**	**19.86**	**296916.22**	**16.89**	**6.92**	**299416.08**

37.75	520.65	35.11	0.75	4.82	3.12	46615.85	2.65	1.09	47008.32
0.16	2.21	0.15	0.00	0.02	0.01	197.94	0.01	0.00	199.61
0.32	4.42	0.30	0.01	0.04	0.03	395.89	0.02	0.01	399.22
0.16	2.21	0.15	0.00	0.02	0.01	197.94	0.01	0.00	199.61
145.97	2012.94	135.73	2.88	18.63	12.06	180228.15	10.25	4.20	181745.56
56.11	773.78	52.17	1.11	7.16	4.63	69280.45	3.94	1.61	69863.75
240.47	**3316.22**	**223.60**	**4.75**	**30.69**	**19.86**	**296916.22**	**16.89**	**6.92**	**299416.08**

Marin-Sonoma Counties Mosquito and Vector Control District Vehicles and Equipments

Land Surveillance and Applications/Management	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
05 Dodge 2500 4X4 truck	5.9 liter				50%	50%		100%	Diesel
1 gal back can sprayer	N/A							0%	Zero
12v Argo tank	Electric 12v							0%	Zero
12v Spray tank for bike	Electric 12v							0%	Zero
2000 Gal Water truck 97 Ford Louisville (Alpine) GW 33,000lbs	7.9 liter				50%	50%		100%	Diesel
2000 Gal Water truck 99 Int 4700 (Alpine) GW 33,000lbs	7.6 liter				50%	50%		100%	Diesel
2500 Gal Water Truck 01 Int 8000 (Alpine) GW 52,000lbs	10.3 liter				50%	50%		100%	Diesel
3 gal back can sprayer	N/A							0%	Zero
30-gallon sprayer	Electric 12v							0%	Zero
40 foot portable lift (Ameriquip)	Electric (battery operated)							0%	Zero
5 x 8 trailer	N/A							0%	Zero
50-gallon sprayer	Electric 12v							0%	Zero
6 x 10 trailer	N/A							0%	Zero
6 x 12 GO-4 trailer	N/A							0%	Zero
7 x 14 Flatbed trailer	N/A							0%	Zero
99 Ford F550 Flat Bed 4X4 truck	7.3 liter				50%	50%		100%	Diesel
Agnique spray bottle	N/A							0%	Zero
Arctic Cat 500 TBX (off road)	30.5 cubic inches 31hp	50%			40%	10%		100%	Gasoline
Argo Avenger (off road)	41.1 cubic inches 26 hp	60%	5%	5%	15%	15%		100%	Gasoline
Argo Conquest (off road)	37.8 cubic inches 21 hp	60%	5%	5%	15%	15%		100%	Gasoline
Argo seeder	Electric 12v							0%	Zero
Backpack fogger (Curtis Dynaflow)	40 cc					100%		100%	50:1 gas/oil mix
Ball Mix Trailer 1000 Gal Tank	N/A							0%	Zero
Becomist Fogger	Electric 12v					100%		100%	Zero
Big Mix Trailer 800 Gal Tank	N/A							0%	Zero
Bike seeder	Electric 12v							0%	Zero
Bike Sprayer	Electric 12v							0%	Zero
Boat trailer	N/A							0%	Zero
Chevy 1500 truck	3.6 liter	60%	5%	10%	15%	10%		100%	Gasoline
Chevy 3500 truck	454 cu in						100%	100%	Diesel
Chevy HD 2500 truck	6.0 liter	50%	5%	10%	20%	15%		100%	Diesel
Chevy Traverse	3.6 liter						100%	100%	Gasoline
Chevy W4500	6.0 liter						100%	100%	Diesel
Dondi Rotary Ditcher DMR 35-B	N/A		100%					100%	Zero
Dump Truck 5 ton	390 cu in						100%	100%	Diesel
Echo backpack blower	40.2 cc							0%	50:1 gas/oil mix
Echo Chainsaw	30.1 cc			100%				100%	50:1 gas/oil mix
Echo hand held blower	17 cc							0%	50:1 gas/oil mix
Echo hedge trimmer	21.2 cc			100%				100%	50:1 gas/oil mix
Electramist fogger	Electric 12v					100%		100%	Zero
EVS Mosquito Trap	Electric 6v							0%	Zero
Faye Mosquito Trap	N/A							0%	Zero
Ford E-150 Van	4.2 liter						100%	100%	Gasoline
Ford Explorer	4.0 liter						100%	100%	Gasoline
Ford Explorer 4x4	4.0 liter						100%	100%	Gasoline
Ford F-150 truck 4x4	4.6 liter	65%	5%	10%	10%	10%		100%	Gasoline
Ford F-250 truck	Varied 5.4 liter to 6.2 liter	50%	5%	10%	20%	15%		100%	Gasoline
Ford F-250 truck 4x4	Varied 5.4 liter to 6.2 liter	50%	5%	10%	20%	15%		100%	Gasoline
Ford F-350 truck	460 cu in	50%	5%	10%	25%	10%		100%	Diesel
Ford F-550 4x4	6.0 liter		25%	25%	25%	25%		100%	Diesel
Ford Ranger truck 2x4	3.0 liter	70%			15%	15%		100%	Gasoline
Ford Ranger truck 4x4	3.0 liter	80%					20%	100%	Gasoline
Gator (off road)	37.7 cubic inches 18hp	70%	10%	10%	5%	5%		100%	Gasoline
GO-4 Catch Basin Rig	60.9 cubic inches 55hp	50%			20%	30%		100%	Gasoline
GO-4 Spray tank	Electric 12v							0%	Zero
Hand fogger	3.0 cu in					100%		100%	50:1 gas/oil mix
High Pressure sprayer	41.9 cu in 21 hp				60%	40%		100%	Gasoline
Horn seeder	N/A							0%	Zero
Husqavarna Chainsaw	55.5 cc			100%				100%	50:1 gas/oil mix
Husqavarna Weedeater	21.7 cc			100%				100%	50:1 gas/oil mix
Intelli sprayer 150	14.8 cu in 9 hp				60%	40%		100%	Gasoline
Intelli sprayer 50	14.8 cu in 9 hp				60%	40%		100%	Gasoline
Intelli Truck 3500	5.7 liter				50%	50%		100%	Diesel
John Deere Tractor	41.5 cubic inches: output 43.7hp			100%				100%	Diesel
Kawasaki 400 (off road)	23.8 cubic inches 26.5hp	50%			40%	10%		100%	Gasoline
Kawasaki 650 (off road)	36.8 cubic inches 42hp	50%	3%	3%	35%	10%		100%	Gasoline
Kelly seeder	N/A							0%	Zero
Komatsu (off road)	Komatsu 3D94-2 35hp		50%	50%				100%	Gasoline
Lite Foot Sprayer	hydraulic							0%	Zero
Lite Foot trailer	N/A							0%	Zero
Mozzie Fog Fogger	10.1 cu in 5.5 hp					100%		100%	Gasoline
Mozzie granular applicator	Electric 12v				50%	50%		100%	Zero
New Jersey Light Mosquito Trap	Electric 110v							0%	Zero
Nifty-Fifty	5.5 cu in 3 hp							0%	Gasoline
Nifty-Fifty with Intelli reel	5.5 cu in 3 hp	10%		50%	40%			100%	Gasoline
Old Suzuki tank	Electric 12v							0%	Zero
Pistenbully Mower 72F-H (off road)	N/A			100%				100%	Zero
Pistenbully PB100 (off road)	242.3 cubic inches: 170hp		100%					100%	Diesel
Solo MD 150 DX	40.2 cc				70%	30%		100%	50:1 gas/oil mix
Solo MD 155DX	40.2 cc				70%	30%		100%	50:1 gas/oil mix
Spryte (off road)	300 cubic inches 132 hp							0%	Gasoline
Spryte seeder	19.4 cu in							0%	Gasoline

Spryte tank	N/A		0%	Zero
Spryte/Komatsu trailer	N/A		0%	Zero
Suzuki trailer	N/A		0%	Zero
Tilt trailer	N/A		0%	Zero
Toyota Prius HB Three	1.8 liter hybrid	100%	100%	Gasoline
Trailer for Airboat	N/A		0%	Zero
Yellowjacket Duster	N/A		0%	Zero

Water Surveillance and Applications/Management	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
Airboat	502 cubic inches: output 500hp	50%			40%	10%		100%	Gasoline
Airboat spray tank	7.4 cu in				50%	50%		100%	Gasoline
Boat trailer	N/A							0%	Zero
Flat bottom boat	123 cc 4 hp	100%						100%	Gasoline
Grizzly 17 ft. Boat	60.8 cu in	100%						100%	Gasoline
Klamath Boat	100 cc 9.9 hp	70%			15%	15%		100%	50:1 gas/oil mix

Aerial Applications	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
1960 Hiller Soloy helicopter (Alpine) 120 gal material tank	Allison 250-C20J turboshaft, 420 shp					70%	30%	100%	Jet A
1968 Bell 206 Jet Ranger helicopter (Alpine) 120 gal material tank	Allison 250-C20J turboshaft, 420 shp				70%	30%		100%	Jet A
1989 Bell 206 Jet Ranger helicopter (Alpine) 120 gal material tank	Allison 250-C20J turboshaft, 420 shp				70%	30%		100%	Jet A
800 gallon mix trailer	Transfer pump					60%	40%	100%	Gasoline
Isolair 4400 bucket system (helicopter-mounted)	N/A							0%	Zero
Isolair 4500 broadcaster (helicopter-mounted)	N/A							0%	Zero
Isolair Air spray system model 3900 (helicopter-mounted)	N/A							0%	Zero
		100.00%	20%	5%	13%	21%	25%	15%	6000%

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Onroad MD				MD	1	3	3	3	2		30
None				0	1						
Electric				0	1						
Electric				0	1						
Onroad HD				HD	1	1	1	1	1		30
Onroad HD				HD	1	1	2	2	1		30
Onroad HD				HD	1	2	2	2	1		60
None				0	1						
Electric				0	1						
Electric				0	1						
None				0	1						
Electric				0	1						
None				0	1						
None				0	1						
None				0	1						
Onroad MD				MD	1	1	2	2	1		30
None				0	1						
Sport				31	2	5	5	5	1	1	
Sport				26	5	20	20	20	10	1	
Sport				21	4	20	20	20	10	1	
Electric				0	1						
2-stroke	40	2.4	0.92	2.2	5	2	20	10	1	0.5	
None				0	1						
Electric				0	3	2	15	10	2		
None				0	1						
Electric				0	1						
Electric				0	1						
None				0	1						
Onroad LD				LD	2	35	50	50	30		45
Onroad MD				MD	1	4	15	15	2		30
Onroad MD				MD	3	50	66	66	45		60
Onroad LD				LD	1	6	6	6	3		45
Onroad MD				MD	1	0	1	3	0		30
None				0	1	1	0	0	1		
Onroad HD				HD	1	0	0	0	2		30
2-stroke	40	2.4	0.92	2.2	1					0.5	
2-stroke	30	1.8	0.92	1.7	1	10	0	0	10	0.5	
2-stroke	17	1.0	0.92	1.0	1					1	
2-stroke	21	1.3	0.92	1.2	1	5	0	0	5	1	
Electric				0	1	1	3	3	2		
Electric				0	1						
None				0	1						
Onroad LD				LD	1	0	7	7	1		30
Onroad LD				LD	3	32	48	48	32		30
Onroad LD				LD	1	0	2	2	1		30
Onroad LD				LD	5	10	15	15	5		15
Onroad LD				LD	12	50	60	60	40		45
Onroad LD				LD	9	45	60	60	40		60
Onroad MD				MD	3	10	15	15	5		90
Onroad MD				MD	2	5	15	15	2		90
Onroad LD				LD	3	15	40	40	5		90
Onroad LD				LD	1	3	5	5	1		45
Sport				18	1	0	1	1	0	0.5	
Sport				55	1	1	5	5	5	1	
Electric				0	1						
2-stroke	49	3.0	0.92	2.8	21	2	15	10	5	0.5	
Utility	615	37.5	0.56	21.0	1	1	10	10	1	0.5	
None				0	1						
2-stroke	56	3.4	0.92	3.1	2	5	0	0	5	0.5	
2-stroke	22	1.3	0.92	1.2	2	10	0	0	10	0.5	
Utility	264	16.1	0.56	9.0	1	5	10	10	1	1	
Utility	264	16.1	0.56	9.0	1	5	10	10	1	1	
Onroad MD				MD	1	3	4	1	0		30
Offroad				44	1	0	2	1	0	1	
Sport				27	1	5	5	5	1	2	
Sport				42	3	10	20	30	15	1	
None				0	1						
Sport				35	1	0	2	2	0	2	
None				0	1						
None				0	1						
Utility	160	9.8	0.56	5.5	1	0	3	3	0	1	
Electric				0	1	3	3	3	2		
Electric				0	1						
Utility	88	5.4	0.56	3.0	1					1	
Utility	88	5.4	0.56	3.0	1	10	15	15	1	1	
Electric				0	1						
None				0	1	0	1	1	0		
Offroad				170	1	1	0	0	1	2	
2-stroke	40	2.4	0.92	2.2	5	10	30	30	15	1	
2-stroke	40	2.4	0.92	2.2	2	10	30	30	15	1	
Utility				132	1					2	
Utility	318	19.4	0.56	11.0	1					2	

None				0	1						
None				0	1						
None				0	1						
None				0	1						
Onroad LD				LD	1	63	63	63	63		60
None				0	1						
None				0	1						

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Sport				500	1	2	10	10	5	1	
Utility	122	7.4	0.56	4.2	1	2	4	4	1	1	
None				0	1						
Utility	118	7.2	0.56	4.0	1	1	1	1	1	1	
Sport	996	60.8	0.86	52.0	1	1	1	1	1	1	
2-stroke	177	10.8	0.92	9.9	1	1	1	1	1	0.5	

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Turbine				420	1	1		1	1	2	
Turbine				420	1	2	5	5	2	2	
Turbine				420	1	2	5	5	2	2	
Utility				5	1		2	2	2	0.5	
None				0	1						
None				0	1						
None				0	1						

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
	30		90		330
	30		30		120
	30		60		180
	60		120		420
	30		60		180
2		10		32	
5		100		350	
4		80		280	
2.5		50		82.5	
	90		4500		14850
	30		450		1080
	180		11880		40860
	45		270		945
	30		90		120
	30		60		60
0.5		0		0	
0.5		5		10	
1		0		0	
1		5		10	
	30		210		450
	90		4320		14400
	30		60		150
	75		1125		3375
	540		32400		113400
	540		32400		110700
	270		4050		12150
	180		2700		6660
	270		10800		27000
	45		225		630
0.5		0.5		1	
1		5		16	
10.5		157.5		336	
0.5		5		11	
1		5		10	
1		10		20	
1		10		26	
1		10		26	
	30		120		240
1		2		3	
2		10		32	
3		90		225	
2		4		8	
1		3		6	
1		0		0	
1		15		41	
2		2		4	
5		150		425	
2		60		170	
2		0		0	
2		0		0	

60	3780	15120

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
1		10		27	
1		4		11	
1		1		4	
1		1		4	
0.5		0.5		2	

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
2		2		6	
2		10		28	
2		10		28	
0.5		1		3	

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.00190	0.01284	0.01425	0.00003	0.00055	0.00046	2.79845	0.00009	0.00014	2.84273
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00202	0.00846	0.02418	0.00004	0.00118	0.00101	4.21279	0.00009	0.00009	4.24176
0.00202	0.00846	0.02418	0.00004	0.00118	0.00101	4.21279	0.00009	0.00009	4.24176
0.00202	0.00846	0.02418	0.00004	0.00118	0.00101	4.21279	0.00009	0.00009	4.24176
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00190	0.01284	0.01425	0.00003	0.00055	0.00046	2.79845	0.00009	0.00014	2.84273
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.17577	5.83110	0.15159	0.00781	0.00930	0.00605	14.62890	0.00083	0.00036	14.75872
0.14742	4.89060	0.12714	0.00655	0.00780	0.00507	12.26940	0.00069	0.00030	12.37828
0.11907	3.95010	0.10269	0.00529	0.00630	0.00410	9.90990	0.00056	0.00025	9.99784
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.08138	1.45578	0.00904	0.00131	0.01722	0.01119	2.24939	0.00013	0.00006	2.26935
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00190	0.01284	0.01425	0.00003	0.00055	0.00046	2.79845	0.00009	0.00014	2.84273
0.00190	0.01284	0.01425	0.00003	0.00055	0.00046	2.79845	0.00009	0.00014	2.84273
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00190	0.01284	0.01425	0.00003	0.00055	0.00046	2.79845	0.00009	0.00014	2.84273
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00202	0.00846	0.02418	0.00004	0.00118	0.00101	4.21279	0.00009	0.00009	4.24176
0.08138	1.45578	0.00904	0.00131	0.01722	0.01119	2.24939	0.00013	0.00006	2.26935
0.06288	1.12492	0.00699	0.00101	0.01330	0.00865	1.73817	0.00010	0.00004	1.75359
0.03699	0.66172	0.00411	0.00060	0.00783	0.00509	1.02245	0.00006	0.00003	1.03152
0.04439	0.79406	0.00493	0.00071	0.00939	0.00610	1.22694	0.00007	0.00003	1.23783
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00190	0.01284	0.01425	0.00003	0.00055	0.00046	2.79845	0.00009	0.00014	2.84273
0.00190	0.01284	0.01425	0.00003	0.00055	0.00046	2.79845	0.00009	0.00014	2.84273
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.10206	3.38580	0.08802	0.00454	0.00540	0.00351	8.49420	0.00048	0.00021	8.56958
0.31185	10.34550	0.26895	0.01386	0.01650	0.01073	25.95450	0.00147	0.00064	26.18482
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.10357	1.85281	0.01151	0.00167	0.02191	0.01424	2.86286	0.00016	0.00007	2.88827
0.19845	6.58350	0.17115	0.00882	0.01050	0.00683	16.51650	0.00093	0.00041	16.66307
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.16513	1.53659	0.01835	0.00185	0.02426	0.01577	2.92578	0.00017	0.00007	2.95174
0.04439	0.79406	0.00493	0.00071	0.00939	0.00610	1.22694	0.00007	0.00003	1.23783
0.04514	4.51284	0.03846	0.00387	0.00437	0.00284	7.78635	0.00044	0.00019	7.85545
0.04514	4.51284	0.03846	0.00387	0.00437	0.00284	7.78635	0.00044	0.00019	7.85545
0.00190	0.01284	0.01425	0.00003	0.00055	0.00046	2.79845	0.00009	0.00014	2.84273
0.03906	0.23871	0.28645	0.00029	0.02604	0.02214	30.12240	0.00172	0.00076	30.39337
0.15309	5.07870	0.13203	0.00680	0.00810	0.00527	12.74130	0.00072	0.00032	12.85437
0.23814	7.90020	0.20538	0.01058	0.01260	0.00819	19.81980	0.00112	0.00049	19.99568
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.19845	6.58350	0.17115	0.00882	0.01050	0.00683	16.51650	0.00093	0.00041	16.66307
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.02759	2.75785	0.02350	0.00236	0.00267	0.00173	4.75833	0.00027	0.00012	4.80055
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.01505	1.50428	0.01282	0.00129	0.00146	0.00095	2.59545	0.00015	0.00006	2.61848
0.01505	1.50428	0.01282	0.00129	0.00146	0.00095	2.59545	0.00015	0.00006	2.61848
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.13281	0.83845	0.97395	0.00111	0.05031	0.04276	116.38200	0.00664	0.00293	117.42894
0.08138	1.45578	0.00904	0.00131	0.01722	0.01119	2.24939	0.00013	0.00006	2.26935
0.08138	1.45578	0.00904	0.00131	0.01722	0.01119	2.24939	0.00013	0.00006	2.26935
1.24740	41.38200	1.07580	0.05544	0.06600	0.04290	103.81800	0.00587	0.00257	104.73929
0.10395	3.44850	0.08965	0.00462	0.00550	0.00358	8.65150	0.00049	0.00021	8.72827

0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
2.83500	94.05000	2.44500	0.12600	0.15000	0.09750	235.95000	0.01335	0.00585	238.04385
0.02107	2.10599	0.01795	0.00181	0.00204	0.00132	3.63363	0.00021	0.00009	3.66588
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.02006	2.00571	0.01709	0.00172	0.00194	0.00126	3.46060	0.00020	0.00009	3.49131
0.29484	9.78120	0.25428	0.01310	0.01560	0.01014	24.53880	0.00139	0.00061	24.75656
0.52734	4.90716	0.05859	0.00589	0.07748	0.05036	9.34362	0.00053	0.00023	9.42654

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.00136	0.01094	2.91816	0.00515	0.03979	0.02587	541.59840	0.01497	0.01735	547.29131
0.00136	0.01094	2.91816	0.00515	0.03979	0.02587	541.59840	0.01497	0.01735	547.29131
0.00136	0.01094	2.91816	0.00515	0.03979	0.02587	541.59840	0.01497	0.01735	547.29131
0.02508	2.50713	0.02136	0.00215	0.00243	0.00158	4.32575	0.00024	0.00011	4.36414
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Surveillance	20%
Physical Control	5%
Vegetation Management	13%
Biological Control	21%
Chemical Control	25%
Other Non-Chemical	15%
CHECKSUM	**100%**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
0.06	0.39	0.43	0.00	0.02	0.01	83.95	0.00	0.00	85.28
0.06	0.25	0.73	0.00	0.04	0.03	126.38	0.00	0.00	127.25
0.06	0.25	0.73	0.00	0.04	0.03	126.38	0.00	0.00	127.25
0.12	0.51	1.45	0.00	0.07	0.06	252.77	0.01	0.01	254.51
0.06	0.39	0.43	0.00	0.02	0.01	83.95	0.00	0.00	85.28
0.35	11.66	0.30	0.02	0.02	0.01	29.26	0.00	0.00	29.52
0.74	24.45	0.64	0.03	0.04	0.03	61.35	0.00	0.00	61.89
0.48	15.80	0.41	0.02	0.03	0.02	39.64	0.00	0.00	39.99
0.20	3.64	0.02	0.00	0.04	0.03	5.62	0.00	0.00	5.67
0.06	0.59	0.06	0.00	0.01	0.01	99.23	0.01	0.00	100.06
0.06	0.39	0.43	0.00	0.02	0.01	83.95	0.00	0.00	85.28
0.34	2.31	2.57	0.00	0.10	0.08	503.72	0.02	0.02	511.69
0.03	0.30	0.03	0.00	0.00	0.00	49.62	0.00	0.00	50.03
0.06	0.39	0.43	0.00	0.02	0.01	83.95	0.00	0.00	85.28
0.06	0.25	0.73	0.00	0.04	0.03	126.38	0.00	0.00	127.25
0.04	0.73	0.00	0.00	0.01	0.01	1.12	0.00	0.00	1.13
0.03	0.56	0.00	0.00	0.01	0.00	0.87	0.00	0.00	0.88
0.04	0.66	0.00	0.00	0.01	0.01	1.02	0.00	0.00	1.03
0.04	0.79	0.00	0.00	0.01	0.01	1.23	0.00	0.00	1.24
0.02	0.20	0.02	0.00	0.00	0.00	33.08	0.00	0.00	33.35
0.06	0.59	0.06	0.00	0.01	0.01	99.23	0.01	0.00	100.06
0.02	0.20	0.02	0.00	0.00	0.00	33.08	0.00	0.00	33.35
0.05	0.50	0.05	0.00	0.01	0.00	82.69	0.00	0.00	83.39
0.38	3.57	0.35	0.01	0.05	0.03	595.39	0.03	0.01	600.38
0.38	3.57	0.35	0.01	0.05	0.03	595.39	0.03	0.01	600.38
0.51	3.47	3.85	0.01	0.15	0.12	755.58	0.02	0.04	767.54
0.34	2.31	2.57	0.00	0.10	0.08	503.72	0.02	0.02	511.69
0.19	1.78	0.18	0.00	0.02	0.02	297.69	0.02	0.01	300.19
0.03	0.30	0.03	0.00	0.00	0.00	49.62	0.00	0.00	50.03
0.05	1.69	0.04	0.00	0.00	0.00	4.25	0.00	0.00	4.28
0.31	10.35	0.27	0.01	0.02	0.01	25.95	0.00	0.00	26.18
1.09	19.45	0.12	0.02	0.23	0.15	30.06	0.00	0.00	30.33
0.10	3.29	0.09	0.00	0.01	0.00	8.26	0.00	0.00	8.33
0.17	1.54	0.02	0.00	0.02	0.02	2.93	0.00	0.00	2.95
0.04	0.79	0.00	0.00	0.01	0.01	1.23	0.00	0.00	1.24
0.05	4.51	0.04	0.00	0.00	0.00	7.79	0.00	0.00	7.86
0.05	4.51	0.04	0.00	0.00	0.00	7.79	0.00	0.00	7.86
0.06	0.39	0.43	0.00	0.02	0.01	83.95	0.00	0.00	85.28
0.04	0.24	0.29	0.00	0.03	0.02	30.12	0.00	0.00	30.39
0.31	10.16	0.26	0.01	0.02	0.01	25.48	0.00	0.00	25.71
0.71	23.70	0.62	0.03	0.04	0.02	59.46	0.00	0.00	59.99
0.40	13.17	0.34	0.02	0.02	0.01	33.03	0.00	0.00	33.33
0.03	2.76	0.02	0.00	0.00	0.00	4.76	0.00	0.00	4.80
0.02	1.50	0.01	0.00	0.00	0.00	2.60	0.00	0.00	2.62
0.02	1.50	0.01	0.00	0.00	0.00	2.60	0.00	0.00	2.62
0.27	1.68	1.95	0.00	0.10	0.09	232.76	0.01	0.01	234.86
0.41	7.28	0.05	0.01	0.09	0.06	11.25	0.00	0.00	11.35
0.16	2.91	0.02	0.00	0.03	0.02	4.50	0.00	0.00	4.54
2.49	82.76	2.15	0.11	0.13	0.09	207.64	0.01	0.01	209.48
0.21	6.90	0.18	0.01	0.01	0.01	17.30	0.00	0.00	17.46

0.04	0.40	0.04	0.00	0.01	0.00	66.15	0.00	0.00	66.71
11.88	**282.27**	**23.84**	**0.37**	**1.70**	**1.24**	**5675.73**	**0.25**	**0.19**	**5739.06**
VOC	**CO**	**NO_X**	**SO_X**	**PM_{10}**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_20**	**CO_2 eqv**
lbs/day	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**
2.84	94.05	2.45	0.13	0.15	0.10	235.95	0.01	0.01	238.04
0.02	2.11	0.02	0.00	0.00	0.00	3.63	0.00	0.00	3.67
0.02	2.01	0.02	0.00	0.00	0.00	3.46	0.00	0.00	3.49
0.29	9.78	0.25	0.01	0.02	0.01	24.54	0.00	0.00	24.76
0.26	2.45	0.03	0.00	0.04	0.03	4.67	0.00	0.00	4.71
3.43	**110.40**	**2.76**	**0.15**	**0.21**	**0.14**	**272.25**	**0.02**	**0.01**	**274.67**
VOC	**CO**	**NO_X**	**SO_X**	**PM_{10}**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_20**	**CO_2 eqv**
lbs/day	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**	**lbs/day**
0.00	0.02	5.84	0.01	0.08	0.05	1083.20	0.03	0.03	1094.58
0.00	0.02	5.84	0.01	0.08	0.05	1083.20	0.03	0.03	1094.58
0.00	0.02	5.84	0.01	0.08	0.05	1083.20	0.03	0.03	1094.58
0.01	1.25	0.01	0.00	0.00	0.00	2.16	0.00	0.00	2.18
0.02	**1.32**	**17.52**	**0.03**	**0.24**	**0.16**	**3251.75**	**0.09**	**0.10**	**3285.93**
15.34	**393.99**	**44.12**	**0.55**	**2.15**	**1.53**	**9199.74**	**0.35**	**0.30**	**9299.66**
3.05	78.47	8.79	0.11	0.43	0.31	1832.28	0.07	0.06	1852.18
0.84	21.51	2.41	0.03	0.12	0.08	502.15	0.02	0.02	507.61
2.06	53.02	5.94	0.07	0.29	0.21	1238.13	0.05	0.04	1251.58
3.26	83.72	9.38	0.12	0.46	0.33	1954.95	0.07	0.06	1976.18
3.85	98.83	11.07	0.14	0.54	0.38	2307.60	0.09	0.07	2332.66
2.27	58.44	6.55	0.08	0.32	0.23	1364.63	0.05	0.04	1379.45
15.34	**393.99**	**44.12**	**0.55**	**2.15**	**1.53**	**9199.74**	**0.35**	**0.30**	**9299.66**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
0.2	1.2	1.3	0.0	0.0	0.0	251.9	0.0	0.0	255.8
0.1	0.3	0.7	0.0	0.0	0.0	126.4	0.0	0.0	127.3
0.1	0.5	1.5	0.0	0.1	0.1	252.8	0.0	0.0	254.5
0.2	1.0	2.9	0.0	0.1	0.1	505.5	0.0	0.0	509.0
0.1	0.8	0.9	0.0	0.0	0.0	167.9	0.0	0.0	170.6
1.8	58.3	1.5	0.1	0.1	0.1	146.3	0.0	0.0	147.6
14.7	489.1	12.7	0.7	0.8	0.5	1226.9	0.1	0.0	1237.8
9.5	316.0	8.2	0.4	0.5	0.3	792.8	0.0	0.0	799.8
4.1	72.8	0.5	0.1	0.9	0.6	112.5	0.0	0.0	113.5
3.2	29.7	2.9	0.0	0.4	0.3	4961.6	0.3	0.1	5003.2
0.9	5.8	6.4	0.0	0.2	0.2	1259.3	0.0	0.1	1279.2
22.5	152.6	169.3	0.3	6.5	5.4	33245.6	1.0	1.6	33771.6
0.2	1.8	0.2	0.0	0.0	0.0	297.7	0.0	0.0	300.2
0.2	1.2	1.3	0.0	0.0	0.0	251.9	0.0	0.0	255.8
0.1	0.5	1.5	0.0	0.1	0.1	252.8	0.0	0.0	254.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.3	5.6	0.0	0.0	0.1	0.0	8.7	0.0	0.0	8.8
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.2	4.0	0.0	0.0	0.0	0.0	6.1	0.0	0.0	6.2
0.1	1.4	0.1	0.0	0.0	0.0	231.5	0.0	0.0	233.5
3.0	28.5	2.8	0.0	0.4	0.3	4763.1	0.3	0.1	4803.1
0.0	0.4	0.0	0.0	0.0	0.0	66.2	0.0	0.0	66.7
0.8	7.4	0.7	0.0	0.1	0.1	1240.4	0.1	0.0	1250.8
22.8	214.0	21.2	0.3	3.0	1.9	35723.3	2.0	0.8	36023.0
22.8	214.0	21.2	0.3	3.0	1.9	35723.3	2.0	0.8	36023.0
7.7	52.0	57.7	0.1	2.2	1.8	11333.7	0.4	0.6	11513.0
5.1	34.7	38.5	0.1	1.5	1.2	7555.8	0.2	0.4	7675.4
7.6	71.3	7.1	0.1	1.0	0.6	11907.8	0.7	0.3	12007.7
0.2	1.5	0.1	0.0	0.0	0.0	248.1	0.0	0.0	250.2
0.1	1.7	0.0	0.0	0.0	0.0	4.2	0.0	0.0	4.3
1.6	51.7	1.3	0.1	0.1	0.1	129.8	0.0	0.0	130.9
16.3	291.8	1.8	0.3	3.5	2.2	450.9	0.0	0.0	454.9
1.0	32.9	0.9	0.0	0.1	0.0	82.6	0.0	0.0	83.3
0.8	7.7	0.1	0.0	0.1	0.1	14.6	0.0	0.0	14.8
0.4	7.9	0.0	0.0	0.1	0.1	12.3	0.0	0.0	12.4
0.5	45.1	0.4	0.0	0.0	0.0	77.9	0.0	0.0	78.6
0.5	45.1	0.4	0.0	0.0	0.0	77.9	0.0	0.0	78.6
0.2	1.5	1.7	0.0	0.1	0.1	335.8	0.0	0.0	341.1
0.1	0.5	0.6	0.0	0.1	0.0	60.2	0.0	0.0	60.8
1.5	50.8	1.3	0.1	0.1	0.1	127.4	0.0	0.0	128.5
21.4	711.0	18.5	1.0	1.1	0.7	1783.8	0.1	0.0	1799.6
0.8	26.3	0.7	0.0	0.0	0.0	66.1	0.0	0.0	66.7
0.1	8.3	0.1	0.0	0.0	0.0	14.3	0.0	0.0	14.4
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.2	22.6	0.2	0.0	0.0	0.0	38.9	0.0	0.0	39.3
0.3	1.7	1.9	0.0	0.1	0.1	232.8	0.0	0.0	234.9
12.2	218.4	1.4	0.2	2.6	1.7	337.4	0.0	0.0	340.4
4.9	87.3	0.5	0.1	1.0	0.7	135.0	0.0	0.0	136.2
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

2.7	25.0	2.5	0.0	0.3	0.2	4167.7	0.2	0.1	4202.7
193.90	**3403.51**	**395.67**	**4.57**	**30.57**	**21.85**	**160809.42**	**7.76**	**5.13**	**162563.77**
VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
28.4	940.5	24.5	1.3	1.5	1.0	2359.5	0.1	0.1	2380.4
0.1	8.4	0.1	0.0	0.0	0.0	14.5	0.0	0.0	14.7
0.0	2.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0	3.5
0.3	9.8	0.3	0.0	0.0	0.0	24.5	0.0	0.0	24.8
0.3	2.5	0.0	0.0	0.0	0.0	4.7	0.0	0.0	4.7
29.01	**963.16**	**24.82**	**1.28**	**1.56**	**1.02**	**2406.71**	**0.14**	**0.06**	**2428.06**
VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
0.0	0.0	5.8	0.0	0.1	0.1	1083.2	0.0	0.0	1094.6
0.0	0.1	29.2	0.1	0.4	0.3	5416.0	0.1	0.2	5472.9
0.0	0.1	29.2	0.1	0.4	0.3	5416.0	0.1	0.2	5472.9
0.0	2.5	0.0	0.0	0.0	0.0	4.3	0.0	0.0	4.4
0.05	**2.75**	**64.22**	**0.12**	**0.88**	**0.57**	**11919.49**	**0.33**	**0.38**	**12044.77**
222.97	**4369.43**	**484.71**	**5.97**	**33.01**	**23.43**	**175135.62**	**8.22**	**5.58**	**177036.60**

44.41	870.24	96.54	1.19	6.58	4.67	34881.18	1.64	1.11	35259.79
12.17	238.50	26.46	0.33	1.80	1.28	9559.49	0.45	0.30	9663.25
30.01	588.05	65.23	0.80	4.44	3.15	23570.34	1.11	0.75	23826.18
47.38	928.50	103.00	1.27	7.02	4.98	37216.32	1.75	1.18	37620.28
55.93	1096.00	121.58	1.50	8.28	5.88	43929.85	2.06	1.40	44406.68
33.07	648.13	71.90	0.89	4.90	3.48	25978.45	1.22	0.83	26260.43
222.97	**4369.43**	**484.71**	**5.97**	**33.01**	**23.43**	**175135.62**	**8.22**	**5.58**	**177036.60**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
0.6	4.2	4.7	0.0	0.2	0.2	923.5	0.0	0.0	938.1
0.2	1.0	2.9	0.0	0.1	0.1	505.5	0.0	0.0	509.0
0.4	1.5	4.4	0.0	0.2	0.2	758.3	0.0	0.0	763.5
0.8	3.6	10.2	0.0	0.5	0.4	1769.4	0.0	0.0	1781.5
0.3	2.3	2.6	0.0	0.1	0.1	503.7	0.0	0.0	511.7
5.6	186.6	4.9	0.2	0.3	0.2	468.1	0.0	0.0	472.3
51.6	1711.7	44.5	2.3	2.7	1.8	4294.3	0.2	0.1	4332.4
33.3	1106.0	28.8	1.5	1.8	1.1	2774.8	0.2	0.1	2799.4
6.7	120.1	0.7	0.1	1.4	0.9	185.6	0.0	0.0	187.2
10.4	98.1	9.7	0.2	1.4	0.9	16373.2	0.9	0.4	16510.5
2.0	13.9	15.4	0.0	0.6	0.5	3022.3	0.1	0.1	3070.1
77.5	524.8	582.3	1.1	22.4	18.6	114344.9	3.6	5.6	116153.8
0.7	6.2	0.6	0.0	0.1	0.1	1041.9	0.1	0.0	1050.7
0.2	1.5	1.7	0.0	0.1	0.1	335.8	0.0	0.0	341.1
0.1	0.5	1.5	0.0	0.1	0.1	252.8	0.0	0.0	254.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.6	11.2	0.1	0.0	0.1	0.1	17.4	0.0	0.0	17.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.4	7.9	0.0	0.0	0.1	0.1	12.3	0.0	0.0	12.4
0.3	3.0	0.3	0.0	0.0	0.0	496.2	0.0	0.0	500.3
10.1	95.1	9.4	0.2	1.3	0.9	15877.0	0.9	0.4	16010.2
0.1	1.0	0.1	0.0	0.0	0.0	165.4	0.0	0.0	166.8
2.4	22.3	2.2	0.0	0.3	0.2	3721.2	0.2	0.1	3752.4
79.6	748.8	74.3	1.2	10.4	6.7	125031.7	7.2	2.9	126080.4
77.7	731.0	72.5	1.2	10.2	6.6	122054.7	7.0	2.8	123078.5
23.0	156.0	173.2	0.3	6.7	5.5	34001.2	1.1	1.7	34539.1
12.6	85.5	94.9	0.2	3.7	3.0	18637.7	0.6	0.9	18932.6
19.0	178.3	17.7	0.3	2.5	1.6	29769.4	1.7	0.7	30019.1
0.4	4.2	0.4	0.0	0.1	0.0	694.6	0.0	0.0	700.4
0.1	3.4	0.1	0.0	0.0	0.0	8.5	0.0	0.0	8.6
5.0	165.5	4.3	0.2	0.3	0.2	415.3	0.0	0.0	419.0
34.8	622.5	3.9	0.6	7.4	4.8	961.9	0.1	0.0	970.5
2.2	72.4	1.9	0.1	0.1	0.1	181.7	0.0	0.0	183.3
1.7	15.4	0.2	0.0	0.2	0.2	29.3	0.0	0.0	29.5
0.9	15.9	0.1	0.0	0.2	0.1	24.5	0.0	0.0	24.8
1.2	117.3	1.0	0.1	0.1	0.1	202.4	0.0	0.0	204.2
1.2	117.3	1.0	0.1	0.1	0.1	202.4	0.0	0.0	204.2
0.5	3.1	3.4	0.0	0.1	0.1	671.6	0.0	0.0	682.3
0.1	0.7	0.9	0.0	0.1	0.1	90.4	0.0	0.0	91.2
4.9	162.5	4.2	0.2	0.3	0.2	407.7	0.0	0.0	411.3
53.6	1777.5	46.2	2.4	2.8	1.8	4459.5	0.3	0.1	4499.0
1.6	52.7	1.4	0.1	0.1	0.1	132.1	0.0	0.0	133.3
0.2	16.5	0.1	0.0	0.0	0.0	28.5	0.0	0.0	28.8
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.6	61.7	0.5	0.1	0.1	0.0	106.4	0.0	0.0	107.4
0.5	3.4	3.9	0.0	0.2	0.2	465.5	0.0	0.0	469.7
34.6	618.7	3.8	0.6	7.3	4.8	956.0	0.1	0.0	964.5
13.8	247.5	1.5	0.2	2.9	1.9	382.4	0.0	0.0	385.8
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

10.6	99.8	9.9	0.2	1.4	0.9	16670.9	1.0	0.4	16810.7
585.06	**10000.43**	**1248.16**	**13.74**	**91.04**	**65.37**	**524430.01**	**25.44**	**16.61**	**530113.64**
VOC	**CO**	**NO_X**	**SO_X**	**PM_{10}**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_20**	**CO_2 eqv**
lbs/yr	**lbs/yr**	**lbs/yr**	**lbs/yr**	**lbs/yr**	**lbs/yr**	**lbs/yr**	**lbs/yr**	**lbs/yr**	**lbs/yr**
76.5	2539.4	66.0	3.4	4.1	2.6	6370.7	0.4	0.2	6427.2
0.2	23.2	0.2	0.0	0.0	0.0	40.0	0.0	0.0	40.3
0.1	8.0	0.1	0.0	0.0	0.0	13.8	0.0	0.0	14.0
1.2	39.1	1.0	0.1	0.1	0.0	98.2	0.0	0.0	99.0
1.1	9.8	0.1	0.0	0.2	0.1	18.7	0.0	0.0	18.9
79.09	**2619.48**	**67.42**	**3.49**	**4.30**	**2.79**	**6541.30**	**0.37**	**0.16**	**6599.35**
VOC	**CO**	**NO_X**	**SO_X**	**PM_{10}**	**$PM_{2.5}$**	**CO_2**	**CH_4**	**N_20**	**CO_2 eqv**
lbs/yr	**lbs/yr**	**lbs/yr**	**lbs/yr**	**lbs/yr**	**lbs/yr**	**lbs/yr**	**lbs/yr**	**lbs/yr**	**lbs/yr**
0.0	0.1	17.5	0.0	0.2	0.2	3249.6	0.1	0.1	3283.7
0.0	0.3	81.7	0.1	1.1	0.7	15164.8	0.4	0.5	15324.2
0.0	0.3	81.7	0.1	1.1	0.7	15164.8	0.4	0.5	15324.2
0.1	7.5	0.1	0.0	0.0	0.0	13.0	0.0	0.0	13.1
0.16	**8.20**	**180.99**	**0.33**	**2.47**	**1.61**	**33592.08**	**0.93**	**1.08**	**33945.15**
664.31	**12628.11**	**1496.57**	**17.56**	**97.81**	**69.77**	**564563.40**	**26.74**	**17.85**	**570658.15**

132.31	2515.10	298.07	3.50	19.48	13.90	112442.21	5.33	3.55	113656.08
36.26	689.28	81.69	0.96	5.34	3.81	30815.75	1.46	0.97	31148.42
89.41	1699.53	201.41	2.36	13.16	9.39	75980.82	3.60	2.40	76801.08
141.17	2683.47	318.02	3.73	20.79	14.83	119969.72	5.68	3.79	121264.86
166.63	3167.55	375.39	4.40	24.54	17.50	141611.32	6.71	4.48	143140.09
98.54	1873.17	221.99	2.60	14.51	10.35	83743.57	3.97	2.65	84647.63
664.31	**12628.11**	**1496.57**	**17.56**	**97.81**	**69.77**	**564563.40**	**26.74**	**17.85**	**570658.15**

Napa County Mosquito Abatement District Vehicles and Equipments

Land Surveillance and Applications/Management	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
2003 Toyota	3.4L	20%				70%	10%	100%	Gasoline
2005 Toyota	3.4L	20%				70%	10%	100%	Gasoline
2007 Chevy	6.0L	40%			30%		30%	100%	Gasoline
2008 Chevy A	6.0L	20%	5%	20%	15%	35%	5%	100%	Gasoline
2008 Chevy B	6.0L	36%	5%	20%	5%	29%	5%	100%	Gasoline
2008 Jeep Wrangler	5.0L	50%					50%	100%	Gasoline
2009 Chevy A	6.0L	36%	5%	20%	5%	29%	5%	100%	Gasoline
2009 Chevy B	6.0L	25%	4%	18%	21%	27%	5%	100%	Gasoline
2010 Chevy	6.0L	36%	5%	20%	5%	29%	5%	100%	Gasoline
2011 Toyota	4.0L	50%					50%	100%	Gasoline
Daewoo Forklift	2.7L		100%					100%	LPG
Echo Chainsaw CS330T	Echo 32.5cc		100%					100%	50:1 gas/oil mix
FloTech Trash Pump	ProPower 5.5hp		100%					100%	Gasoline
Hand Sprayer – London Fog Colt	Techumseh 49cc					100%		100%	50:1 gas/oil mix
Hand Sprayer – London Fog Colt	Techumseh 49cc					100%		100%	50:1 gas/oil mix
Intellispray 5SDE	Honda GX120 9.2			40%		60%		100%	Gasoline
Intellispray 5SDE	Honda GX120 9.2			40%		60%		100%	Gasoline
Intellispray 5SDE	Honda GX120 9.2			40%		60%		100%	Gasoline
Intellispray 5SDE	Honda GX120 9.2			40%		60%		100%	Gasoline
Intellispray 5SDE	Honda GX120 9.2			40%		60%		100%	Gasoline
Intellispray 9TBE	Honda GX270			40%		60%		100%	Gasoline
JD9 ULV	Honda GX240 242cc					100%		100%	Gasoline
London Fog 18-20 ULV	Honda GX120 7.0					100%		100%	Gasoline
London Fog 18-20 ULV	Honda GX120 7.0					100%		100%	Gasoline
London Fog XKE	Honda GX120 7.0					100%		100%	Gasoline
Maruyama Back Sprayer	Kawasaki 40.2cc					100%		100%	50:1 gas/oil mix
Maruyama Back Sprayer	Kawasaki 40.2cc					100%		100%	50:1 gas/oil mix
Maruyama Back Sprayer	Kawasaki 40.2cc					100%		100%	50:1 gas/oil mix
Northstar Pressure Washer	Honda GX390		100%					100%	Gasoline
Pioneer Backpack Fogger	Electric					100%		100%	Zero
Stihl Blower BR420	Stihl 40.2cc		100%					100%	50:1 gas/oil mix
Stihl Weed Wacker	Stihl 40.2cc		100%					100%	50:1 gas/oil mix
Wisconsin Robin ULV	Wisconsin 252cc					100%		100%	Gasoline

Water Surveillance and Applications/Management	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
Argo ATV 1	725cc	30%				70%		100%	Gasoline
Argo ATV 2	725cc	30%				70%		100%	Gasoline
Argo ATV 3	725cc	30%				70%		100%	Gasoline
Argo Sprayer 1	Honda GX120 7.0					100%		100%	Gasoline
Argo Sprayer 2	Honda GX120 7.0					100%		100%	Gasoline
Argo Sprayer 3	Honda GX120 7.0					100%		100%	Gasoline
Polaris ATV 1	499cc	35%				65%		100%	Gasoline
Polaris ATV 2	499cc	35%				65%		100%	Gasoline
Polaris Spot Sprayer	ShurFlo					100%		100%	Zero
Polaris Sprayer - 50 gal Stainless Steel Tank	Honda GX120 7.0					100%		100%	Gasoline
Tracker Boat	Mercury 4 stroke (15 hp)	40%				60%		100%	Gasoline

Aerial Applications	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
1960 Hiller Soloy helicopter (Alpine) 120 gal material tank	Allison 250-C20J turboshaft, 420 shp					100%		100%	Jet A
1968 Bell 206 Jet Ranger helicopter (Alpine) 120 gal material tank	Allison 250-C20J turboshaft, 420 shp					100%		100%	Jet A
1989 Bell 206 Jet Ranger helicopter (Alpine) 120 gal material tank	Allison 250-C20J turboshaft, 420 shp					100%		100%	Jet A
Isolair 4400 bucket system (helicopter-mounted)	N/A					100%		100%	Zero
Isolair Air spray system model 3900 (helicopter-mounted)	N/A					100%		100%	Zero

100.00%	11%	13%	7%	2%	64%	4%	4900%	

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Onroad LD				LD	1	4	26	18	3		45
Onroad LD				LD	1	4	28	20	11		39
Onroad LD				LD	1	32	22	22	10		27
Onroad LD				LD	1	44	45	47	36		63
Onroad LD				LD	1	53	59	54	48		93
Onroad LD				LD	1	5	5	12	0		60
Onroad LD				LD	1	55	53	56	40		117
Onroad LD				LD	1	50	57	54	46		75
Onroad LD				LD	1	55	54	57	51		135
Onroad LD				LD	1	29	37	50	20		66
Propane	2700	164.8	0.56	92.0	1	0	0	0	1	0.5	
2-stroke	33	2.0	0.92	1.9	1	0	0	0	1	0.5	
Utility	160	9.8	0.56	5.5	1	0	0	0	1	0.5	
2-stroke	49	3.0	0.92	2.8	1	0	6	2	0	0.5	
2-stroke	49	3.0	0.92	2.8	1	0	6	2	0	0.5	
Utility	120	7.3	0.56	4.1	1	9	21	22	26	4.9	
Utility	120	7.3	0.56	4.1	1	6	21	4	27	3.8	
Utility	120	7.3	0.56	4.1	1	4	7	0	25	3.7	
Utility	120	7.3	0.56	4.1	1	0	5	0	22	2.4	
Utility	120	7.3	0.56	4.1	1	0	5	0	22	2.4	
Utility	270	16.5	0.56	9.2	1	4	15	1	28	4.8	
Utility	240	14.6	0.56	8.2	1	0	3	2	0	1.8	
Utility	120	7.3	0.56	4.1	1	0	13	6	0	1.1	
Utility	120	7.3	0.56	4.1	1	0	8	1	0	0.7	
Utility	120	7.3	0.56	4.1	1	0	5	0	0	0.4	
2-stroke	40	2.4	0.92	2.2	1	12	17	9	6	3.9	
2-stroke	40	2.4	0.92	2.2	1	3	6	2	0	2.5	
2-stroke	40	2.4	0.92	2.2	1	3	6	2	0	2.5	
Utility	390	23.8	0.56	13.0	1	0	0	0	1	0.5	
Electric				0	1	0	12	10	0	0.8	
2-stroke	40	2.4	0.92	2.2	1	0	0	0	1	0.5	
2-stroke	40	2.4	0.92	2.2	1	0	0	0	1	0.5	
Utility	252	15.4	0.56	8.6	1	1	3	4	0	1.9	

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Sport	725	44.2	0.86	38.0	1	5	6	2	2	5	
Sport	725	44.2	0.86	38.0	1	6	15	2	0	2.9	
Sport	725	44.2	0.86	38.0	1	6	6	1	1	3.9	
Utility	120	7.3	0.56	4.1	1	5	6	2	2	4.8	
Utility	120	7.3	0.56	4.1	1	6	15	2	0	2.8	
Utility	120	7.3	0.56	4.1	1	6	6	1	1	3.8	
Sport	499	30.5	0.86	26.0	1	4	7	6	3	3.4	
Sport	499	30.5	0.86	26.0	1	2	3	4	0	2.2	
Electric				0	1	3	4	3	1	3.4	
Utility	120	7.3	0.56	4.1	1	3	4	3	1	3.4	
Sport	286	17.5	0.86	15.0	1	3	6	6	3	3.5	

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Turbine				420	1	4	2	2	0	3	
Turbine				420	1	4	2	2	0	3	
Turbine				420	1	4	2	2	0	3	
None				0	1	2	0	0	0	1	
None				0	1	6	0	0	0	2	

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
	45		1170		2295
	39		1092		2457
	27		864		2322
	63		2961		10836
	93		5487		19902
	60		720		1320
	117		6552		23868
	75		4275		15525
	135		7695		29295
	66		3300		8976
0.5		0.5		0.5	
0.5		0.5		0.5	
0.5		0.5		0.5	
0.5		3		4	
0.5		3		4	
4.9		127.4		382.2	
3.8		102.6		220.4	
3.7		92.5		133.2	
2.4		52.8		64.8	
2.4		52.8		64.8	
4.8		134.4		230.4	
1.8		5.4		9	
1.1		14.3		20.9	
0.7		5.6		6.3	
0.4		2		2	
3.9		66.3		171.6	
2.5		15		27.5	
2.5		15		27.5	
0.5		0.5		0.5	
0.8		9.6		17.6	
0.5		0.5		0.5	
0.5		0.5		0.5	
1.9		7.6		15.2	

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
5		30		75	
2.9		43.5		66.7	
3.9		23.4		54.6	
4.8		28.8		72	
2.8		42		64.4	
3.8		22.8		53.2	
3.4		23.8		68	
2.2		8.8		19.8	
3.4		13.6		37.4	
3.4		13.6		37.4	
3.5		21		63	

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
3		12		24	
3		12		24	
3		12		24	
1		2		2	
2		12		12	

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.73030	0.30746	0.46754	0.00033	0.00552	0.00359	75.73440	0.00006	0.00017	75.78690
0.07028	1.25727	0.00781	0.00113	0.01487	0.00967	1.94266	0.00011	0.00005	1.95989
0.02759	2.75785	0.02350	0.00236	0.00267	0.00173	4.75833	0.00027	0.00012	4.80055
0.10357	1.85281	0.01151	0.00167	0.02191	0.01424	2.86286	0.00016	0.00007	2.88827
0.10357	1.85281	0.01151	0.00167	0.02191	0.01424	2.86286	0.00016	0.00007	2.88827
0.02057	2.05585	0.01752	0.00176	0.00199	0.00129	3.54712	0.00020	0.00009	3.57859
0.02057	2.05585	0.01752	0.00176	0.00199	0.00129	3.54712	0.00020	0.00009	3.57859
0.02057	2.05585	0.01752	0.00176	0.00199	0.00129	3.54712	0.00020	0.00009	3.57859
0.02057	2.05585	0.01752	0.00176	0.00199	0.00129	3.54712	0.00020	0.00009	3.57859
0.02057	2.05585	0.01752	0.00176	0.00199	0.00129	3.54712	0.00020	0.00009	3.57859
0.04615	4.61313	0.03931	0.00396	0.00446	0.00290	7.95938	0.00045	0.00020	8.03001
0.04113	4.11170	0.03504	0.00353	0.00398	0.00259	7.09423	0.00040	0.00018	7.15719
0.02057	2.05585	0.01752	0.00176	0.00199	0.00129	3.54712	0.00020	0.00009	3.57859
0.02057	2.05585	0.01752	0.00176	0.00199	0.00129	3.54712	0.00020	0.00009	3.57859
0.02057	2.05585	0.01752	0.00176	0.00199	0.00129	3.54712	0.00020	0.00009	3.57859
0.08138	1.45578	0.00904	0.00131	0.01722	0.01119	2.24939	0.00013	0.00006	2.26935
0.08138	1.45578	0.00904	0.00131	0.01722	0.01119	2.24939	0.00013	0.00006	2.26935
0.08138	1.45578	0.00904	0.00131	0.01722	0.01119	2.24939	0.00013	0.00006	2.26935
0.12285	4.07550	0.10595	0.00546	0.00650	0.00423	10.22450	0.00058	0.00025	10.31523
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.08138	1.45578	0.00904	0.00131	0.01722	0.01119	2.24939	0.00013	0.00006	2.26935
0.08138	1.45578	0.00904	0.00131	0.01722	0.01119	2.24939	0.00013	0.00006	2.26935
0.04314	4.31227	0.03675	0.00370	0.00417	0.00271	7.44029	0.00042	0.00018	7.50632

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.21546	7.14780	0.18582	0.00958	0.01140	0.00741	17.93220	0.00101	0.00044	18.09133
0.21546	7.14780	0.18582	0.00958	0.01140	0.00741	17.93220	0.00101	0.00044	18.09133
0.21546	7.14780	0.18582	0.00958	0.01140	0.00741	17.93220	0.00101	0.00044	18.09133
0.02057	2.05585	0.01752	0.00176	0.00199	0.00129	3.54712	0.00020	0.00009	3.57859
0.02057	2.05585	0.01752	0.00176	0.00199	0.00129	3.54712	0.00020	0.00009	3.57859
0.02057	2.05585	0.01752	0.00176	0.00199	0.00129	3.54712	0.00020	0.00009	3.57859
0.14742	4.89060	0.12714	0.00655	0.00780	0.00507	12.26940	0.00069	0.00030	12.37828
0.14742	4.89060	0.12714	0.00655	0.00780	0.00507	12.26940	0.00069	0.00030	12.37828
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.02057	2.05585	0.01752	0.00176	0.00199	0.00129	3.54712	0.00020	0.00009	3.57859
0.08505	2.82150	0.07335	0.00378	0.00450	0.00293	7.07850	0.00040	0.00018	7.14132

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.00136	0.01094	2.91816	0.00515	0.03979	0.02587	541.59840	0.01497	0.01735	547.29131
0.00136	0.01094	2.91816	0.00515	0.03979	0.02587	541.59840	0.01497	0.01735	547.29131
0.00136	0.01094	2.91816	0.00515	0.03979	0.02587	541.59840	0.01497	0.01735	547.29131
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Surveillance	11%
Physical Control	13%
Vegetation Management	7%
Biological Control	2%
Chemical Control	64%
Other Non-Chemical	4%
CHECKSUM	**100%**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
0.03	0.30	0.03	0.00	0.00	0.00	49.62	0.00	0.00	50.03
0.03	0.26	0.03	0.00	0.00	0.00	43.00	0.00	0.00	43.36
0.02	0.18	0.02	0.00	0.00	0.00	29.77	0.00	0.00	30.02
0.04	0.42	0.04	0.00	0.01	0.00	69.46	0.00	0.00	70.04
0.07	0.61	0.06	0.00	0.01	0.01	102.54	0.01	0.00	103.40
0.04	0.40	0.04	0.00	0.01	0.00	66.15	0.00	0.00	66.71
0.08	0.77	0.08	0.00	0.01	0.01	129.00	0.01	0.00	130.08
0.05	0.50	0.05	0.00	0.01	0.00	82.69	0.00	0.00	83.39
0.09	0.89	0.09	0.00	0.01	0.01	148.85	0.01	0.00	150.10
0.05	0.44	0.04	0.00	0.01	0.00	72.77	0.00	0.00	73.38
0.37	0.15	0.23	0.00	0.00	0.00	37.87	0.00	0.00	37.89
0.04	0.63	0.00	0.00	0.01	0.00	0.97	0.00	0.00	0.98
0.01	1.38	0.01	0.00	0.00	0.00	2.38	0.00	0.00	2.40
0.05	0.93	0.01	0.00	0.01	0.01	1.43	0.00	0.00	1.44
0.05	0.93	0.01	0.00	0.01	0.01	1.43	0.00	0.00	1.44
0.10	10.07	0.09	0.01	0.01	0.01	17.38	0.00	0.00	17.54
0.08	7.81	0.07	0.01	0.01	0.00	13.48	0.00	0.00	13.60
0.08	7.61	0.06	0.01	0.01	0.00	13.12	0.00	0.00	13.24
0.05	4.93	0.04	0.00	0.00	0.00	8.51	0.00	0.00	8.59
0.05	4.93	0.04	0.00	0.00	0.00	8.51	0.00	0.00	8.59
0.22	22.14	0.19	0.02	0.02	0.01	38.21	0.00	0.00	38.54
0.07	7.40	0.06	0.01	0.01	0.00	12.77	0.00	0.00	12.88
0.02	2.26	0.02	0.00	0.00	0.00	3.90	0.00	0.00	3.94
0.01	1.44	0.01	0.00	0.00	0.00	2.48	0.00	0.00	2.51
0.01	0.82	0.01	0.00	0.00	0.00	1.42	0.00	0.00	1.43
0.32	5.68	0.04	0.01	0.07	0.04	8.77	0.00	0.00	8.85
0.20	3.64	0.02	0.00	0.04	0.03	5.62	0.00	0.00	5.67
0.20	3.64	0.02	0.00	0.04	0.03	5.62	0.00	0.00	5.67
0.06	2.04	0.05	0.00	0.00	0.00	5.11	0.00	0.00	5.16
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.04	0.73	0.00	0.00	0.01	0.01	1.12	0.00	0.00	1.13
0.04	0.73	0.00	0.00	0.01	0.01	1.12	0.00	0.00	1.13
0.08	8.19	0.07	0.01	0.01	0.01	14.14	0.00	0.00	14.26
2.67	**102.84**	**1.54**	**0.09**	**0.35**	**0.23**	**999.24**	**0.05**	**0.02**	**1007.41**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
1.08	35.74	0.93	0.05	0.06	0.04	89.66	0.01	0.00	90.46
0.62	20.73	0.54	0.03	0.03	0.02	52.00	0.00	0.00	52.46
0.84	27.88	0.72	0.04	0.04	0.03	69.94	0.00	0.00	70.56
0.10	9.87	0.08	0.01	0.01	0.01	17.03	0.00	0.00	17.18
0.06	5.76	0.05	0.00	0.01	0.00	9.93	0.00	0.00	10.02
0.08	7.81	0.07	0.01	0.01	0.00	13.48	0.00	0.00	13.60
0.50	16.63	0.43	0.02	0.03	0.02	41.72	0.00	0.00	42.09
0.32	10.76	0.28	0.01	0.02	0.01	26.99	0.00	0.00	27.23
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.07	6.99	0.06	0.01	0.01	0.00	12.06	0.00	0.00	12.17
0.30	9.88	0.26	0.01	0.02	0.01	24.77	0.00	0.00	24.99
3.97	**152.03**	**3.42**	**0.19**	**0.22**	**0.15**	**357.58**	**0.02**	**0.01**	**360.75**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
0.00	0.03	8.75	0.02	0.12	0.08	1624.80	0.04	0.05	1641.87
0.00	0.03	8.75	0.02	0.12	0.08	1624.80	0.04	0.05	1641.87
0.00	0.03	8.75	0.02	0.12	0.08	1624.80	0.04	0.05	1641.87
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.01	**0.10**	**26.26**	**0.05**	**0.36**	**0.23**	**4874.39**	**0.13**	**0.16**	**4925.62**

6.65	**254.97**	**31.22**	**0.33**	**0.93**	**0.60**	**6231.21**	**0.21**	**0.19**	**6293.79**

0.72	27.73	3.40	0.04	0.10	0.07	677.80	0.02	0.02	684.61
0.85	32.47	3.98	0.04	0.12	0.08	793.52	0.03	0.02	801.49
0.46	17.59	2.15	0.02	0.06	0.04	429.83	0.01	0.01	434.14
0.11	4.21	0.52	0.01	0.02	0.01	103.01	0.00	0.00	104.04
4.27	163.86	20.06	0.21	0.60	0.39	4004.50	0.13	0.12	4044.72
0.24	9.11	1.12	0.01	0.03	0.02	222.54	0.01	0.01	224.78
6.65	**254.97**	**31.22**	**0.33**	**0.93**	**0.60**	**6231.21**	**0.21**	**0.19**	**6293.79**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
0.8	7.7	0.8	0.0	0.1	0.1	1290.0	0.1	0.0	1300.8
0.8	7.2	0.7	0.0	0.1	0.1	1204.0	0.1	0.0	1214.1
0.6	5.7	0.6	0.0	0.1	0.1	952.6	0.1	0.0	960.6
2.1	19.6	1.9	0.0	0.3	0.2	3264.7	0.2	0.1	3292.1
3.9	36.2	3.6	0.1	0.5	0.3	6049.8	0.3	0.1	6100.6
0.5	4.8	0.5	0.0	0.1	0.0	793.9	0.0	0.0	800.5
4.6	43.3	4.3	0.1	0.6	0.4	7224.1	0.4	0.2	7284.6
3.0	28.2	2.8	0.0	0.4	0.3	4713.5	0.3	0.1	4753.0
5.4	50.8	5.0	0.1	0.7	0.5	8484.3	0.5	0.2	8555.5
2.3	21.8	2.2	0.0	0.3	0.2	3638.5	0.2	0.1	3669.0
0.4	0.2	0.2	0.0	0.0	0.0	37.9	0.0	0.0	37.9
0.0	0.6	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0
0.0	1.4	0.0	0.0	0.0	0.0	2.4	0.0	0.0	2.4
0.3	5.6	0.0	0.0	0.1	0.0	8.6	0.0	0.0	8.7
0.3	5.6	0.0	0.0	0.1	0.0	8.6	0.0	0.0	8.7
2.6	261.9	2.2	0.2	0.3	0.2	451.9	0.0	0.0	455.9
2.1	210.9	1.8	0.2	0.2	0.1	363.9	0.0	0.0	367.2
1.9	190.2	1.6	0.2	0.2	0.1	328.1	0.0	0.0	331.0
1.1	108.5	0.9	0.1	0.1	0.1	187.3	0.0	0.0	188.9
1.1	108.5	0.9	0.1	0.1	0.1	187.3	0.0	0.0	188.9
6.2	620.0	5.3	0.5	0.6	0.4	1069.7	0.1	0.0	1079.2
0.2	22.2	0.2	0.0	0.0	0.0	38.3	0.0	0.0	38.6
0.3	29.4	0.3	0.0	0.0	0.0	50.7	0.0	0.0	51.2
0.1	11.5	0.1	0.0	0.0	0.0	19.9	0.0	0.0	20.0
0.0	4.1	0.0	0.0	0.0	0.0	7.1	0.0	0.0	7.2
5.4	96.5	0.6	0.1	1.1	0.7	149.1	0.0	0.0	150.5
1.2	21.8	0.1	0.0	0.3	0.2	33.7	0.0	0.0	34.0
1.2	21.8	0.1	0.0	0.3	0.2	33.7	0.0	0.0	34.0
0.1	2.0	0.1	0.0	0.0	0.0	5.1	0.0	0.0	5.2
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.7	0.0	0.0	0.0	0.0	1.1	0.0	0.0	1.1
0.0	0.7	0.0	0.0	0.0	0.0	1.1	0.0	0.0	1.1
0.3	32.8	0.3	0.0	0.0	0.0	56.5	0.0	0.0	57.0
48.98	**1982.36**	**37.23**	**1.88**	**6.50**	**4.22**	**40658.52**	**2.32**	**0.95**	**41000.71**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
6.5	214.4	5.6	0.3	0.3	0.2	538.0	0.0	0.0	542.7
9.4	310.9	8.1	0.4	0.5	0.3	780.1	0.0	0.0	787.0
5.0	167.3	4.3	0.2	0.3	0.2	419.6	0.0	0.0	423.3
0.6	59.2	0.5	0.1	0.1	0.0	102.2	0.0	0.0	103.1
0.9	86.3	0.7	0.1	0.1	0.1	149.0	0.0	0.0	150.3
0.5	46.9	0.4	0.0	0.0	0.0	80.9	0.0	0.0	81.6
3.5	116.4	3.0	0.2	0.2	0.1	292.0	0.0	0.0	294.6
1.3	43.0	1.1	0.1	0.1	0.0	108.0	0.0	0.0	108.9
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.3	28.0	0.2	0.0	0.0	0.0	48.2	0.0	0.0	48.7
1.8	59.3	1.5	0.1	0.1	0.1	148.6	0.0	0.0	150.0
29.67	**1131.69**	**25.57**	**1.41**	**1.67**	**1.08**	**2666.51**	**0.15**	**0.07**	**2690.17**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
0.0	0.1	35.0	0.1	0.5	0.3	6499.2	0.2	0.2	6567.5
0.0	0.1	35.0	0.1	0.5	0.3	6499.2	0.2	0.2	6567.5
0.0	0.1	35.0	0.1	0.5	0.3	6499.2	0.2	0.2	6567.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.05	**0.39**	**105.05**	**0.19**	**1.43**	**0.93**	**19497.54**	**0.54**	**0.62**	**19702.49**

78.70	**3114.45**	**167.85**	**3.47**	**9.60**	**6.23**	**62822.57**	**3.01**	**1.64**	**63393.37**

8.56	338.78	18.26	0.38	1.04	0.68	6833.56	0.33	0.18	6895.65
10.02	396.62	21.38	0.44	1.22	0.79	8000.26	0.38	0.21	8072.95
5.43	214.83	11.58	0.24	0.66	0.43	4333.48	0.21	0.11	4372.85
1.30	51.48	2.77	0.06	0.16	0.10	1038.50	0.05	0.03	1047.93
50.58	2001.51	107.87	2.23	6.17	4.00	40373.12	1.94	1.05	40739.94
2.81	111.23	5.99	0.12	0.34	0.22	2243.66	0.11	0.06	2264.05
78.70	**3114.45**	**167.85**	**3.47**	**9.60**	**6.23**	**62822.57**	**3.01**	**1.64**	**63393.37**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
1.6	15.2	1.5	0.0	0.2	0.1	2530.4	0.1	0.1	2551.6
1.7	16.2	1.6	0.0	0.2	0.1	2709.0	0.2	0.1	2731.7
1.6	15.3	1.5	0.0	0.2	0.1	2560.2	0.1	0.1	2581.6
7.6	71.6	7.1	0.1	1.0	0.6	11947.5	0.7	0.3	12047.7
14.0	131.4	13.0	0.2	1.8	1.2	21943.4	1.3	0.5	22127.4
0.9	8.7	0.9	0.0	0.1	0.1	1455.4	0.1	0.0	1467.6
16.8	157.6	15.6	0.3	2.2	1.4	26316.2	1.5	0.6	26536.9
10.9	102.5	10.2	0.2	1.4	0.9	17117.4	1.0	0.4	17261.0
20.6	193.5	19.2	0.3	2.7	1.7	32299.8	1.8	0.7	32570.8
6.3	59.3	5.9	0.1	0.8	0.5	9896.7	0.6	0.2	9979.7
0.4	0.2	0.2	0.0	0.0	0.0	37.9	0.0	0.0	37.9
0.0	0.6	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0
0.0	1.4	0.0	0.0	0.0	0.0	2.4	0.0	0.0	2.4
0.4	7.4	0.0	0.0	0.1	0.1	11.5	0.0	0.0	11.6
0.4	7.4	0.0	0.0	0.1	0.1	11.5	0.0	0.0	11.6
7.9	785.7	6.7	0.7	0.8	0.5	1355.7	0.1	0.0	1367.7
4.5	453.1	3.9	0.4	0.4	0.3	781.8	0.0	0.0	788.7
2.7	273.8	2.3	0.2	0.3	0.2	472.5	0.0	0.0	476.7
1.3	133.2	1.1	0.1	0.1	0.1	229.9	0.0	0.0	231.9
1.3	133.2	1.1	0.1	0.1	0.1	229.9	0.0	0.0	231.9
10.6	1062.9	9.1	0.9	1.0	0.7	1833.8	0.1	0.0	1850.1
0.4	37.0	0.3	0.0	0.0	0.0	63.8	0.0	0.0	64.4
0.4	43.0	0.4	0.0	0.0	0.0	74.1	0.0	0.0	74.8
0.1	13.0	0.1	0.0	0.0	0.0	22.3	0.0	0.0	22.5
0.0	4.1	0.0	0.0	0.0	0.0	7.1	0.0	0.0	7.2
14.0	249.8	1.6	0.2	3.0	1.9	386.0	0.0	0.0	389.4
2.2	40.0	0.2	0.0	0.5	0.3	61.9	0.0	0.0	62.4
2.2	40.0	0.2	0.0	0.5	0.3	61.9	0.0	0.0	62.4
0.1	2.0	0.1	0.0	0.0	0.0	5.1	0.0	0.0	5.2
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.7	0.0	0.0	0.0	0.0	1.1	0.0	0.0	1.1
0.0	0.7	0.0	0.0	0.0	0.0	1.1	0.0	0.0	1.1
0.7	65.5	0.6	0.1	0.1	0.0	113.1	0.0	0.0	114.1
131.90	**4126.20**	**104.54**	**4.14**	**17.74**	**11.50**	**134541.23**	**7.70**	**3.13**	**135672.18**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
16.2	536.1	13.9	0.7	0.9	0.6	1344.9	0.1	0.0	1356.8
14.4	476.8	12.4	0.6	0.8	0.5	1196.1	0.1	0.0	1206.7
11.8	390.3	10.1	0.5	0.6	0.4	979.1	0.1	0.0	987.8
1.5	148.0	1.3	0.1	0.1	0.1	255.4	0.0	0.0	257.7
1.3	132.4	1.1	0.1	0.1	0.1	228.4	0.0	0.0	230.5
1.1	109.4	0.9	0.1	0.1	0.1	188.7	0.0	0.0	190.4
10.0	332.6	8.6	0.4	0.5	0.3	834.3	0.0	0.0	841.7
2.9	96.8	2.5	0.1	0.2	0.1	242.9	0.0	0.0	245.1
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.8	76.9	0.7	0.1	0.1	0.0	132.7	0.0	0.0	133.8
5.4	177.8	4.6	0.2	0.3	0.2	445.9	0.0	0.0	449.9
65.26	**2476.94**	**56.24**	**3.09**	**3.66**	**2.38**	**5848.48**	**0.33**	**0.15**	**5900.38**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
0.0	0.3	70.0	0.1	1.0	0.6	12998.4	0.4	0.4	13135.0
0.0	0.3	70.0	0.1	1.0	0.6	12998.4	0.4	0.4	13135.0
0.0	0.3	70.0	0.1	1.0	0.6	12998.4	0.4	0.4	13135.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.10	**0.79**	**210.11**	**0.37**	**2.87**	**1.86**	**38995.08**	**1.08**	**1.25**	**39404.97**

197.27	**6603.93**	**370.88**	**7.61**	**24.27**	**15.74**	**179384.80**	**9.10**	**4.52**	**180977.54**

21.46	718.35	40.34	0.83	2.64	1.71	19512.67	0.99	0.49	19685.92
25.12	840.99	47.23	0.97	3.09	2.00	22844.11	1.16	0.58	23046.94
13.61	455.54	25.58	0.52	1.67	1.09	12373.89	0.63	0.31	12483.76
3.26	109.17	6.13	0.13	0.40	0.26	2965.34	0.15	0.07	2991.67
126.77	4244.04	238.35	4.89	15.59	10.11	115282.19	5.85	2.91	116305.77
7.05	235.85	13.25	0.27	0.87	0.56	6406.60	0.33	0.16	6463.48
197.27	**6603.93**	**370.88**	**7.61**	**24.27**	**15.74**	**179384.80**	**9.10**	**4.52**	**180977.54**

Northern Salinas Valley Mosquito Abatement District Vehicles and Equipments

Land Surveillance and Applications/Management	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
Bean Pump	Honda Gx 160 5.5 HP			100%				100%	Gasoline
Birchmeier Sprayer (backpacks 4)	N/A			50%		50%		100%	Zero
Blow Mite Granule Spreader (backpack)	20 cc					100%		100%	50:1 gas/oil mix
Cat 320 Excavator	138 HP		50%	50%				100%	Diesel
Cat D3 Dozer	5.2 Liter		50%	50%				100%	Diesel
Chevy Silverado 4X4	6.6 Liter			90%			10%	100%	Diesel
Dodge Ram 50 Right hand drive	2.0 Liter				100%			100%	Gasoline
Ford F-150 4X4 (3)	5.4 Liter	25%			25%	40%	10%	100%	Gasoline
Ford F-150 4X4 Flare Side	5.8 Liter					90%	10%	100%	Gasoline
Ford F-150 Xl	5.4 Liter	25%			25%	40%	10%	100%	Gasoline
Ford F-350 4X4	6.0 Liter		50%	50%				100%	Diesel
Ford Windstar Sport SE	3.8 Liter						100%	100%	Gasoline
GPI Model 1505 Fuel Transfer	½ HP						100%	100%	Zero
Jeep Liberty 4X4	3.7 Liter						100%	100%	Gasoline
Jeep Wrangler 4X4	4.0 Liter	25%					75%	100%	Gasoline
John Deere 6420 with Flail Mulch Mower S900 (PTO)	90 hp		30%	70%				100%	Diesel
Maruyama Backpack Blower (Mister/Duster)	40.2 CC					90%	10%	100%	50:1 gas/oil mix
Mozzie Fogger – Arro-Gun System with electric shur flow pump	Honda GX 160 5.5 HP					100%		100%	Gasoline
Mozzie Granular Applicator – Arro-Gun System	Honda GX 160 5.5 HP					100%		100%	Gasoline
Robin Micro Gen Fogger	20 cc					100%		100%	50:1 gas/oil mix
Spyker Hand Granular Spreader (2)	N/A					100%		100%	Zero
Stihl Chainsaw 011AV	2.5 CI			100%				100%	50:1 gas/oil mix
Stihl Chainsaw 028 AV Super	47 CC			100%				100%	50:1 gas/oil mix
Stihl Leaf Blower BG 65	1.66 CI			100%				100%	50:1 gas/oil mix

Water Surveillance and Applications/Management	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
Argo ATV	570 CC	10%			45%	45%		100%	Gasoline
Argo Sprayer System	ShurFlo Electric					100%		100%	Zero
Valco Flat Bottom Boat (go devil engine/prop)	Briggs & Stratton 9 HP			50%		50%		100%	Gasoline

Aerial Applications	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
Jet Ranger (Helicopter)	Rolls Royce					100%		100%	Jet A

	100.00%	3%	6%	29%	7%	39%	15%	2800%

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Utility	160	9.8	0.56	5.5	1	15	15	15	15	1.60	
None				0	4	15	15	15	15	1.60	
2-stroke	20	1.2	0.92	1.1	1	15	15	15	15	0.13	
Offroad	4039	246.5	0.56	138.0	1	9	21	21	9	2.50	
Offroad	5200	317.3	0.56	178.0	1	9	21	21	9	1.67	
Onroad MD				MD	1	15	15	15	15		96
Onroad LD				LD	1	15	15	15	15		5
Onroad LD				LD	3	15	15	15	15		53
Onroad LD				LD	1	15	15	15	15		8
Onroad LD				LD	1	15	15	15	15		160
Onroad MD				MD	1	15	15	15	15		96
Onroad LD				LD	1	15	15	15	15		48
Electric				0	1	15	15	15	15	0.13	
Onroad LD				LD	1	15	15	15	15		12
Onroad LD				LD	1	15	15	15	15		24
Offroad	2635	160.8	0.56	90.0	1	9	21	21	9	1.67	
2-stroke	40	2.4	0.92	2.2	1	15	15	15	15	0.20	
Utility	160	9.8	0.56	5.5	1	15	15	15	15	0.13	
Utility	160	9.8	0.56	5.5	1	15	15	15	15	0.13	
2-stroke	20	1.2	0.92	1.1	1	15	15	15	15	0.13	
None				0	2	15	15	15	15	0.07	
2-stroke	41	2.5	0.92	2.3	1	0	30	30	0	0.13	
2-stroke	47	2.9	0.92	2.6	1	15	15	15	15	0.13	
2-stroke	27	1.6	0.92	1.5	1	0	30	30	0	0.13	

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Sport	570	34.8	0.86	30.0	1	15	15	15	15	1.60	
Electric				0	1	15	15	15	15	1.60	
Utility	264	16.1	0.56	9.0	1	15	15	15	15	1.60	

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Turbine				420	1	15	15	15	15	0.67	

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
1.60		24		96	
6.40		96		384	
0.13		2		8	
2.50		52.5		150	
1.67		35		100	
	96		1440		5760
	5		75		300
	160		2400		9600
	8		120		480
	160		2400		9600
	96		1440		5760
	48		720		2880
0.13		2		8	
	12		180		720
	24		360		1440
1.67		35		100	
0.20		3		12	
0.13		2		8	
0.13		2		8	
0.13		2		8	
0.13		2		8	
0.13		4		8	
0.13		2		8	
0.13		4		8	

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
1.6		24		96	
1.6		24		96	
1.6		24		96	

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
0.67		10		40	

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.02759	2.75785	0.02350	0.00236	0.00267	0.00173	4.75833	0.00027	0.00012	4.80055
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.04069	0.72789	0.00452	0.00065	0.00861	0.00560	1.12470	0.00006	0.00003	1.13468
0.10781	0.68063	0.79061	0.00090	0.04084	0.03471	94.47480	0.00539	0.00238	95.32467
0.13906	0.61454	1.01978	0.00116	0.03512	0.02985	121.85880	0.00695	0.00307	122.95501
0.00190	0.01284	0.01425	0.00003	0.00055	0.00046	2.79845	0.00009	0.00014	2.84273
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00190	0.01284	0.01425	0.00003	0.00055	0.00046	2.79845	0.00009	0.00014	2.84273
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.07990	0.44389	0.58593	0.00059	0.03551	0.03018	61.61400	0.00352	0.00155	62.16826
0.08138	1.45578	0.00904	0.00131	0.01722	0.01119	2.24939	0.00013	0.00006	2.26935
0.02759	2.75785	0.02350	0.00236	0.00267	0.00173	4.75833	0.00027	0.00012	4.80055
0.02759	2.75785	0.02350	0.00236	0.00267	0.00173	4.75833	0.00027	0.00012	4.80055
0.04069	0.72789	0.00452	0.00065	0.00861	0.00560	1.12470	0.00006	0.00003	1.13468
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.08508	1.52195	0.00945	0.00137	0.01800	0.01170	2.35164	0.00013	0.00006	2.37250
0.09618	1.72047	0.01069	0.00155	0.02035	0.01323	2.65837	0.00015	0.00007	2.68196
0.05549	0.99258	0.00617	0.00089	0.01174	0.00763	1.53368	0.00009	0.00004	1.54729

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.17010	5.64300	0.14670	0.00756	0.00900	0.00585	14.15700	0.00080	0.00035	14.28263
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.04514	4.51284	0.03846	0.00387	0.00437	0.00284	7.78635	0.00044	0.00019	7.85545

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.00136	0.01094	2.91816	0.00515	0.03979	0.02587	541.59840	0.01497	0.01735	547.29131

Surveillance	3%
Physical Control	6%
Vegetation Management	29%
Biological Control	7%
Chemical Control	39%
Other Non-Chemical	15%
CHECKSUM	**100%**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
0.04	4.41	0.04	0.00	0.00	0.00	7.61	0.00	0.00	7.68
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.01	0.10	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.15
0.27	1.70	1.98	0.00	0.10	0.09	236.19	0.01	0.01	238.31
0.23	1.02	1.70	0.00	0.06	0.05	203.10	0.01	0.01	204.93
0.18	1.23	1.37	0.00	0.05	0.04	268.65	0.01	0.01	272.90
0.00	0.03	0.00	0.00	0.00	0.00	5.51	0.00	0.00	5.56
0.11	1.06	0.10	0.00	0.01	0.01	176.41	0.01	0.00	177.89
0.01	0.05	0.01	0.00	0.00	0.00	8.82	0.00	0.00	8.89
0.11	1.06	0.10	0.00	0.01	0.01	176.41	0.01	0.00	177.89
0.18	1.23	1.37	0.00	0.05	0.04	268.65	0.01	0.01	272.90
0.03	0.32	0.03	0.00	0.00	0.00	52.92	0.00	0.00	53.37
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.01	0.08	0.01	0.00	0.00	0.00	13.23	0.00	0.00	13.34
0.02	0.16	0.02	0.00	0.00	0.00	26.46	0.00	0.00	26.68
0.13	0.74	0.98	0.00	0.06	0.05	102.69	0.01	0.00	103.61
0.02	0.29	0.00	0.00	0.00	0.00	0.45	0.00	0.00	0.45
0.00	0.37	0.00	0.00	0.00	0.00	0.63	0.00	0.00	0.64
0.00	0.37	0.00	0.00	0.00	0.00	0.63	0.00	0.00	0.64
0.01	0.10	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.15
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.01	0.20	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.32
0.01	0.23	0.00	0.00	0.00	0.00	0.35	0.00	0.00	0.36
0.01	0.13	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.21
1.40	**14.88**	**7.71**	**0.02**	**0.38**	**0.31**	**1549.56**	**0.07**	**0.05**	**1566.88**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
0.27	9.03	0.23	0.01	0.01	0.01	22.65	0.00	0.00	22.85
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.07	7.22	0.06	0.01	0.01	0.00	12.46	0.00	0.00	12.57
0.34	**16.25**	**0.30**	**0.02**	**0.02**	**0.01**	**35.11**	**0.00**	**0.00**	**35.42**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
0.00	0.01	1.95	0.00	0.03	0.02	361.07	0.01	0.01	364.86
0.00	**0.01**	**1.95**	**0.00**	**0.03**	**0.02**	**361.07**	**0.01**	**0.01**	**364.86**

1.75	**31.14**	**9.95**	**0.04**	**0.43**	**0.34**	**1945.73**	**0.09**	**0.06**	**1967.16**

0.05	0.95	0.30	0.00	0.01	0.01	59.07	0.00	0.00	59.72
0.11	2.00	0.64	0.00	0.03	0.02	125.08	0.01	0.00	126.46
0.51	9.01	2.88	0.01	0.12	0.10	562.87	0.03	0.02	569.07
0.12	2.17	0.69	0.00	0.03	0.02	135.51	0.01	0.00	137.00
0.69	12.29	3.93	0.02	0.17	0.13	767.87	0.03	0.02	776.33
0.27	4.73	1.51	0.01	0.07	0.05	295.33	0.01	0.01	298.59
1.75	**31.14**	**9.95**	**0.04**	**0.43**	**0.34**	**1945.73**	**0.09**	**0.06**	**1967.16**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
0.7	66.2	0.6	0.1	0.1	0.0	114.2	0.0	0.0	115.2
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	1.5	0.0	0.0	0.0	0.0	2.2	0.0	0.0	2.3
5.7	35.7	41.5	0.0	2.1	1.8	4959.9	0.3	0.1	5004.5
4.9	21.5	35.7	0.0	1.2	1.0	4265.1	0.2	0.1	4303.4
2.7	18.5	20.5	0.0	0.8	0.7	4029.8	0.1	0.2	4093.5
0.1	0.5	0.0	0.0	0.0	0.0	82.7	0.0	0.0	83.4
1.7	15.8	1.6	0.0	0.2	0.1	2646.2	0.2	0.1	2668.4
0.1	0.8	0.1	0.0	0.0	0.0	132.3	0.0	0.0	133.4
1.7	15.8	1.6	0.0	0.2	0.1	2646.2	0.2	0.1	2668.4
2.7	18.5	20.5	0.0	0.8	0.7	4029.8	0.1	0.2	4093.5
0.5	4.8	0.5	0.0	0.1	0.0	793.9	0.0	0.0	800.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	1.2	0.1	0.0	0.0	0.0	198.5	0.0	0.0	200.1
0.3	2.4	0.2	0.0	0.0	0.0	396.9	0.0	0.0	400.3
2.8	15.5	20.5	0.0	1.2	1.1	2156.5	0.1	0.1	2175.9
0.2	4.4	0.0	0.0	0.1	0.0	6.7	0.0	0.0	6.8
0.1	5.5	0.0	0.0	0.0	0.0	9.5	0.0	0.0	9.6
0.1	5.5	0.0	0.0	0.0	0.0	9.5	0.0	0.0	9.6
0.1	1.5	0.0	0.0	0.0	0.0	2.2	0.0	0.0	2.3
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.3	6.1	0.0	0.0	0.1	0.0	9.4	0.0	0.0	9.5
0.2	3.4	0.0	0.0	0.0	0.0	5.3	0.0	0.0	5.4
0.2	4.0	0.0	0.0	0.0	0.0	6.1	0.0	0.0	6.2
25.11	**249.07**	**143.63**	**0.34**	**7.09**	**5.81**	**26502.95**	**1.31**	**0.84**	**26792.15**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
4.1	135.4	3.5	0.2	0.2	0.1	339.8	0.0	0.0	342.8
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.1	108.3	0.9	0.1	0.1	0.1	186.9	0.0	0.0	188.5
5.17	**243.74**	**4.44**	**0.27**	**0.32**	**0.21**	**526.64**	**0.03**	**0.01**	**531.31**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
0.0	0.1	29.2	0.1	0.4	0.3	5416.0	0.1	0.2	5472.9
0.01	**0.11**	**29.18**	**0.05**	**0.40**	**0.26**	**5415.98**	**0.15**	**0.17**	**5472.91**

30.29	**492.92**	**177.26**	**0.67**	**7.81**	**6.28**	**32445.57**	**1.49**	**1.03**	**32796.38**

0.92	14.96	5.38	0.02	0.24	0.19	984.95	0.05	0.03	995.60
1.95	31.69	11.40	0.04	0.50	0.40	2085.79	0.10	0.07	2108.34
8.76	142.59	51.28	0.19	2.26	1.82	9386.04	0.43	0.30	9487.52
2.11	34.33	12.34	0.05	0.54	0.44	2259.60	0.10	0.07	2284.03
11.95	194.53	69.95	0.26	3.08	2.48	12804.41	0.59	0.41	12942.86
4.60	74.82	26.91	0.10	1.19	0.95	4924.77	0.23	0.16	4978.02
30.29	**492.92**	**177.26**	**0.67**	**7.81**	**6.28**	**32445.57**	**1.49**	**1.03**	**32796.38**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
2.6	264.8	2.3	0.2	0.3	0.2	456.8	0.0	0.0	460.9
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.3	5.8	0.0	0.0	0.1	0.0	9.0	0.0	0.0	9.1
16.2	102.1	118.6	0.1	6.1	5.2	14171.2	0.8	0.4	14298.7
13.9	61.5	102.0	0.1	3.5	3.0	12185.9	0.7	0.3	12295.5
10.9	74.0	82.1	0.2	3.2	2.6	16119.1	0.5	0.8	16374.1
0.2	2.0	0.2	0.0	0.0	0.0	330.8	0.0	0.0	333.5
6.7	63.4	6.3	0.1	0.9	0.6	10584.7	0.6	0.2	10673.5
0.3	3.2	0.3	0.0	0.0	0.0	529.2	0.0	0.0	533.7
6.7	63.4	6.3	0.1	0.9	0.6	10584.7	0.6	0.2	10673.5
10.9	74.0	82.1	0.2	3.2	2.6	16119.1	0.5	0.8	16374.1
2.0	19.0	1.9	0.0	0.3	0.2	3175.4	0.2	0.1	3202.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.5	4.8	0.5	0.0	0.1	0.0	793.9	0.0	0.0	800.5
1.0	9.5	0.9	0.0	0.1	0.1	1587.7	0.1	0.0	1601.0
8.0	44.4	58.6	0.1	3.6	3.0	6161.4	0.4	0.2	6216.8
1.0	17.5	0.1	0.0	0.2	0.1	27.0	0.0	0.0	27.2
0.2	22.1	0.2	0.0	0.0	0.0	38.1	0.0	0.0	38.4
0.2	22.1	0.2	0.0	0.0	0.0	38.1	0.0	0.0	38.4
0.3	5.8	0.0	0.0	0.1	0.0	9.0	0.0	0.0	9.1
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.7	12.2	0.1	0.0	0.1	0.1	18.8	0.0	0.0	19.0
0.8	13.8	0.1	0.0	0.2	0.1	21.3	0.0	0.0	21.5
0.4	7.9	0.0	0.0	0.1	0.1	12.3	0.0	0.0	12.4
84.10	**892.98**	**462.75**	**1.22**	**22.86**	**18.62**	**92973.32**	**4.48**	**3.05**	**94012.84**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
16.3	541.7	14.1	0.7	0.9	0.6	1359.1	0.1	0.0	1371.1
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.3	433.2	3.7	0.4	0.4	0.3	747.5	0.0	0.0	754.1
20.66	**974.96**	**17.77**	**1.10**	**1.28**	**0.83**	**2106.56**	**0.12**	**0.05**	**2125.26**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
0.1	0.4	116.7	0.2	1.6	1.0	21663.9	0.6	0.7	21891.7
0.05	**0.44**	**116.73**	**0.21**	**1.59**	**1.03**	**21663.94**	**0.60**	**0.69**	**21891.65**

104.82	**1868.38**	**597.25**	**2.52**	**25.73**	**20.49**	**116743.82**	**5.20**	**3.80**	**118029.74**

3.18	56.72	18.13	0.08	0.78	0.62	3544.01	0.16	0.12	3583.05
6.74	120.11	38.39	0.16	1.65	1.32	7504.96	0.33	0.24	7587.63
30.32	540.50	172.78	0.73	7.44	5.93	33772.32	1.50	1.10	34144.32
7.30	130.12	41.59	0.18	1.79	1.43	8130.37	0.36	0.26	8219.93
41.36	737.34	235.70	0.99	10.16	8.08	46072.11	2.05	1.50	46579.60
15.91	283.59	90.65	0.38	3.91	3.11	17720.04	0.79	0.58	17915.23
104.82	**1868.38**	**597.25**	**2.52**	**25.73**	**20.49**	**116743.82**	**5.20**	**3.80**	**118029.74**

San Mateo County Mosquito and Vector Control District Vehicles and Equipments

Land Surveillance and Applications/Management	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
Argo Avenger (off road)	Kawasaki 41.1 cubic inches 26 hp	10%			90%			100%	Gasoline
Atlas Tire Balancer	Electric						100%	100%	Zero
Atlas Tire Changer	Electric						100%	100%	Zero
Chevy 2500 pickup truck 4x4	Onroad	25%		25%			50%	100%	Gasoline
Clark Grizzly ULV Truck Mounted Sprayer (2 units)	Briggs & Stratton					100%		100%	Gasoline
Curtis Dyna-Fog Twister XL ULV Backpack Sprayer	40.2 cc					100%		100%	Gasoline
Dewalt 10" Compound Miter Saw DW703	Electric						100%	100%	Zero
Dewalt 14" Multicutter Metal Saw	Electric						100%	100%	Zero
Dodge 2500 4X4 truck 2005	Onroad				100%			100%	Gasoline
Dodge Power Wagon 1948	Onroad						100%	100%	Diesel
ECHO Chainsaw CS 301 (2 units)	30.1 cc			100%				100%	50:1 gas/oil mix
ECHO Weedeater SRM 225	22.5 cc			100%				100%	50:1 gas/oil mix
Ford Escape Hybrid 4x4	Onroad	25%					75%	100%	Gasoline
Ford F-150 pickup truck 4x4 (3 vehicles)	Onroad	60%			25%	15%		100%	Gasoline
Ford Ranger pickup truck 4x4 (8 vehicles)	Onroad	60%	5%	5%	20%	10%		100%	Gasoline
Fork Lift - hydraulic	Offroad (49 hp)						100%	100%	Gasoline
Hotsy High Pressure Washer	Briggs & Stratton						100%	100%	Gasoline
Jeep Wrangler (Right Hand Drive) (8 vehicles)	Onroad				10%	90%		100%	Gasoline
Maruyama Power Mister/Duster Backpack Sprayer	Kawasaki 40.2cc				100%			100%	50:1 gas/oil mix
Nissan Frontier Pro4X pickup truck 4x4 (2 vehicles)	Onroad	60%	5%	5%	20%	10%		100%	Gasoline
Nurse Rig 200 gal tank and sprayer	Briggs & Stratton			80%	20%			100%	Gasoline
Porta-Pak ULV Backpack Sprayer	Kawasaki 40.2cc					100%		100%	50:1 gas/oil mix
Stihl Chainsaw 021	44 cc			100%				100%	50:1 gas/oil mix
Stihl Chainsaw 026	44 cc			100%				100%	50:1 gas/oil mix
Stihl Chainsaw 039	44 cc			100%				100%	50:1 gas/oil mix
Stihl Chainsaw 260	47 cc			100%				100%	50:1 gas/oil mix
Stihl Chainsaw 290	47 cc			100%				100%	50:1 gas/oil mix
Stihl Trimmer HS 85 (6 units)	25.4 cc			100%				100%	50:1 gas/oil mix
Stihl Weedeater FS 250	25.4 cc			100%				100%	50:1 gas/oil mix
Toyota Sienna Van	Onroad	25%					75%	100%	Gasoline
Univar Dynajet ULV Electric Truck Mounted Sprayer (2 units)	Electric					100%		100%	Zero

Water Surveillance and Applications/Management	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
Argo Avenger ATV	Kawasaki 41.1 cubic inches 26 hp	10%			90%			100%	Gasoline
GTO Airboat	502 cubic inches: output 500hp	20%		70%	10%			100%	Gasoline
GTO Airboat 50 gallon spray tank	7.4 cu in			100%				100%	Gasoline
Klamath Boat 14'	Johnson or Mercury 15 hp 4 stroke	80%					20%	100%	Gasoline
Klamath Boat 18'	Johnson or Mercury 15 hp 4 stroke	70%			30%			100%	Gasoline

Aerial Applications	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
1989 Bell 206 Jet Ranger helicopter (Alpine) 120 gal material tank	Allison 250-C20J turboshaft, 420 shp				100%			100%	Jet A
Isolair 4500 broadcaster (helicopter-mounted)	N/A				100%			100%	Zero
Isolair Air spray system model 3900 (helicopter-mounted)	N/A				100%			100%	Zero

100.00%	11%	0%	30%	21%	13%	24%	3900%	

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Sport				49	1	5	5	0	5	4	
Electric				0	1	5	5	5	5	2	
Electric				0	1	5	5	5	5	2	
Onroad LD				LD	1	20	20	20	20		90
Utility	146	8.9	0.56	5.0	2	20	20	20	20	12	
Onroad LD				LD	1	5	10	10	5		30
Electric				0	1	1	1	1	1	1	
Electric				0	1	1	1	1	1	1	
Onroad LD				LD	1	1	1	3	1		150
Onroad MD				MD	1	1	1	1	1		30
2-stroke	30	1.8	0.92	1.7	2	4	10	6	6	2	
2-stroke	23	1.4	0.92	1.3	1		5	5		2	
Onroad LD				LD	1	50	50	50	50		90
Onroad LD				LD	3	180	180	180	180		30
Onroad LD				LD	8	520	520	520	520		90
Utility				49	1	5	5	5	5	1	
Utility	146	8.9	0.56	5.0	1	50	50	50	50	1	
Onroad LD				LD	8	0	240	520	120		120
2-stroke	40	2.4	0.92	2.2	1	5	10	10	5	1	
Onroad LD				LD	2	130	130	130	130		30
Utility	146	8.9	0.56	5.0	1	5	3	30	15	3	
2-stroke	40	2.4	0.92	2.2	1	2	10	10	2	1	
2-stroke	44	2.7	0.92	2.5	1	2	5	3	3	1	
2-stroke	44	2.7	0.92	2.5	1	2	5	3	3	1	
2-stroke	44	2.7	0.92	2.5	1	1	1	1	1	1	
2-stroke	47	2.9	0.92	2.6	1	2	5	3	3	1	
2-stroke	47	2.9	0.92	2.6	1	2	5	3	3	1	
2-stroke	25	1.5	0.92	1.4	6		60	30		6	
2-stroke	25	1.5	0.92	1.4	1		5	5		2	
Onroad LD				LD	1	15	15	15	15		60
Electric				0	2	20	20	20	20	12	

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Sport				26	4	40	20	0	12	16	
Sport				500	1	10	10	20	20	3	
Utility	122	7.4	0.56	4.2	1	0	0	15	15	5	
Sport				15	1	2	2	2	2	3	
Sport				15	1	5	5	5	5	2	

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Turbine				420	1	2	2	2	0	4	
None				0	1	0	2	2	0	2	
None				0	1	2	0	0	0	8	

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
4		20		60	
2		10		40	
2		10		40	
	90		1800		7200
24		480		1920	
	30		300		900
1		1		4	
1		1		4	
	150		450		900
	30		30		120
4		40		104	
2		10		20	
	90		4500		18000
	90		16200		64800
	720		374400		1497600
1		5		20	
1		50		200	
	960		499200		844800
1		10		30	
	60		7800		31200
3		90		159	
1		10		24	
1		5		13	
1		5		13	
1		1		4	
1		5		13	
1		5		13	
36		2160		3240	
2		10		20	
	60		900		3600
24		480		1920	

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
64		2560		4608	
3		60		180	
5		75		150	
3		6		24	
2		10		40	

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
4		8		24	
2		4		8	
8		16		16	

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.27783	9.21690	0.23961	0.01235	0.01470	0.00956	23.12310	0.00131	0.00057	23.32830
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.02508	2.50713	0.02136	0.00215	0.00243	0.00158	4.32575	0.00024	0.00011	4.36414
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00190	0.01284	0.01425	0.00003	0.00055	0.00046	2.79845	0.00009	0.00014	2.84273
0.06288	1.12492	0.00699	0.00101	0.01330	0.00865	1.73817	0.00010	0.00004	1.75359
0.04809	0.86023	0.00534	0.00077	0.01017	0.00661	1.32919	0.00008	0.00003	1.34098
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.46305	15.36150	0.39935	0.02058	0.02450	0.01593	38.53850	0.00218	0.00096	38.88050
0.02508	2.50713	0.02136	0.00215	0.00243	0.00158	4.32575	0.00024	0.00011	4.36414
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.08138	1.45578	0.00904	0.00131	0.01722	0.01119	2.24939	0.00013	0.00006	2.26935
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.02508	2.50713	0.02136	0.00215	0.00243	0.00158	4.32575	0.00024	0.00011	4.36414
0.08138	1.45578	0.00904	0.00131	0.01722	0.01119	2.24939	0.00013	0.00006	2.26935
0.09248	1.65430	0.01028	0.00149	0.01957	0.01272	2.55613	0.00014	0.00006	2.57881
0.09248	1.65430	0.01028	0.00149	0.01957	0.01272	2.55613	0.00014	0.00006	2.57881
0.09248	1.65430	0.01028	0.00149	0.01957	0.01272	2.55613	0.00014	0.00006	2.57881
0.09618	1.72047	0.01069	0.00155	0.02035	0.01323	2.65837	0.00015	0.00007	2.68196
0.09618	1.72047	0.01069	0.00155	0.02035	0.01323	2.65837	0.00015	0.00007	2.68196
0.05179	0.92641	0.00575	0.00083	0.01096	0.00712	1.43143	0.00008	0.00004	1.44413
0.05179	0.92641	0.00575	0.00083	0.01096	0.00712	1.43143	0.00008	0.00004	1.44413
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.14742	4.89060	0.12714	0.00655	0.00780	0.00507	12.26940	0.00069	0.00030	12.37828
2.83500	94.05000	2.44500	0.12600	0.15000	0.09750	235.95000	0.01335	0.00585	238.04385
0.02107	2.10599	0.01795	0.00181	0.00204	0.00132	3.63363	0.00021	0.00009	3.66588
0.08505	2.82150	0.07335	0.00378	0.00450	0.00293	7.07850	0.00040	0.00018	7.14132
0.08505	2.82150	0.07335	0.00378	0.00450	0.00293	7.07850	0.00040	0.00018	7.14132

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.00136	0.01094	2.91816	0.00515	0.03979	0.02587	541.59840	0.01497	0.01735	547.29131
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Surveillance	11%
Physical Control	0%
Vegetation Management	30%
Biological Control	21%
Chemical Control	13%
Other Non-Chemical	24%
CHECKSUM	**100%**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
1.11	36.87	0.96	0.05	0.06	0.04	92.49	0.01	0.00	93.31
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.06	0.59	0.06	0.00	0.01	0.01	99.23	0.01	0.00	100.06
0.60	60.17	0.51	0.05	0.06	0.04	103.82	0.01	0.00	104.74
0.02	0.20	0.02	0.00	0.00	0.00	33.08	0.00	0.00	33.35
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.11	0.99	0.10	0.00	0.01	0.01	165.39	0.01	0.00	166.77
0.06	0.39	0.43	0.00	0.02	0.01	83.95	0.00	0.00	85.28
0.25	4.50	0.03	0.00	0.05	0.03	6.95	0.00	0.00	7.01
0.10	1.72	0.01	0.00	0.02	0.01	2.66	0.00	0.00	2.68
0.06	0.59	0.06	0.00	0.01	0.01	99.23	0.01	0.00	100.06
0.06	0.59	0.06	0.00	0.01	0.01	99.23	0.01	0.00	100.06
0.51	4.75	0.47	0.01	0.07	0.04	793.85	0.05	0.02	800.51
0.46	15.36	0.40	0.02	0.02	0.02	38.54	0.00	0.00	38.88
0.03	2.51	0.02	0.00	0.00	0.00	4.33	0.00	0.00	4.36
0.67	6.34	0.63	0.01	0.09	0.06	1058.47	0.06	0.02	1067.35
0.08	1.46	0.01	0.00	0.02	0.01	2.25	0.00	0.00	2.27
0.04	0.40	0.04	0.00	0.01	0.00	66.15	0.00	0.00	66.71
0.08	7.52	0.06	0.01	0.01	0.00	12.98	0.00	0.00	13.09
0.08	1.46	0.01	0.00	0.02	0.01	2.25	0.00	0.00	2.27
0.09	1.65	0.01	0.00	0.02	0.01	2.56	0.00	0.00	2.58
0.09	1.65	0.01	0.00	0.02	0.01	2.56	0.00	0.00	2.58
0.09	1.65	0.01	0.00	0.02	0.01	2.56	0.00	0.00	2.58
0.10	1.72	0.01	0.00	0.02	0.01	2.66	0.00	0.00	2.68
0.10	1.72	0.01	0.00	0.02	0.01	2.66	0.00	0.00	2.68
1.86	33.35	0.21	0.03	0.39	0.26	51.53	0.00	0.00	51.99
0.10	1.85	0.01	0.00	0.02	0.01	2.86	0.00	0.00	2.89
0.04	0.40	0.04	0.00	0.01	0.00	66.15	0.00	0.00	66.71
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.86	**190.41**	**4.18**	**0.20**	**1.00**	**0.65**	**2898.38**	**0.16**	**0.07**	**2923.48**
VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
9.43	313.00	8.14	0.42	0.50	0.32	785.24	0.04	0.02	792.21
8.51	282.15	7.34	0.38	0.45	0.29	707.85	0.04	0.02	714.13
0.11	10.53	0.09	0.01	0.01	0.01	18.17	0.00	0.00	18.33
0.26	8.46	0.22	0.01	0.01	0.01	21.24	0.00	0.00	21.42
0.17	5.64	0.15	0.01	0.01	0.01	14.16	0.00	0.00	14.28
18.47	**619.79**	**15.93**	**0.83**	**0.98**	**0.64**	**1546.65**	**0.09**	**0.04**	**1560.38**
VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
0.01	0.04	11.67	0.02	0.16	0.10	2166.39	0.06	0.07	2189.17
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.01	**0.04**	**11.67**	**0.02**	**0.16**	**0.10**	**2166.39**	**0.06**	**0.07**	**2189.17**
25.34	**810.24**	**31.79**	**1.05**	**2.14**	**1.39**	**6611.43**	**0.31**	**0.18**	**6673.02**
2.89	92.45	3.63	0.12	0.24	0.16	754.38	0.04	0.02	761.41
0.06	2.08	0.08	0.00	0.01	0.00	16.95	0.00	0.00	17.11
7.70	246.19	9.66	0.32	0.65	0.42	2008.86	0.09	0.05	2027.57
5.29	169.32	6.64	0.22	0.45	0.29	1381.62	0.06	0.04	1394.49
3.41	109.07	4.28	0.14	0.29	0.19	890.00	0.04	0.02	898.29
5.98	191.13	7.50	0.25	0.50	0.33	1559.62	0.07	0.04	1574.15
25.34	**810.24**	**31.79**	**1.05**	**2.14**	**1.39**	**6611.43**	**0.31**	**0.18**	**6673.02**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
5.6	184.3	4.8	0.2	0.3	0.2	462.5	0.0	0.0	466.6
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.3	11.9	1.2	0.0	0.2	0.1	1984.6	0.1	0.0	2001.3
12.0	1203.4	10.3	1.0	1.2	0.8	2076.4	0.1	0.1	2094.8
0.2	2.0	0.2	0.0	0.0	0.0	330.8	0.0	0.0	333.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.3	3.0	0.3	0.0	0.0	0.0	496.2	0.0	0.0	500.3
0.1	0.4	0.4	0.0	0.0	0.0	84.0	0.0	0.0	85.3
2.5	45.0	0.3	0.0	0.5	0.3	69.5	0.0	0.0	70.1
0.5	8.6	0.1	0.0	0.1	0.1	13.3	0.0	0.0	13.4
3.2	29.7	2.9	0.0	0.4	0.3	4961.6	0.3	0.1	5003.2
11.4	107.0	10.6	0.2	1.5	1.0	17861.7	1.0	0.4	18011.5
262.9	2472.4	245.2	4.0	34.4	22.2	412803.0	23.6	9.6	416265.3
2.3	76.8	2.0	0.1	0.1	0.1	192.7	0.0	0.0	194.4
1.3	125.4	1.1	0.1	0.1	0.1	216.3	0.0	0.0	218.2
350.6	3296.5	326.9	5.3	45.9	29.6	550404.0	31.5	12.8	555020.4
0.8	14.6	0.1	0.0	0.2	0.1	22.5	0.0	0.0	22.7
5.5	51.5	5.1	0.1	0.7	0.5	8600.1	0.5	0.2	8672.2
2.3	225.6	1.9	0.2	0.2	0.1	389.3	0.0	0.0	392.8
0.8	14.6	0.1	0.0	0.2	0.1	22.5	0.0	0.0	22.7
0.5	8.3	0.1	0.0	0.1	0.1	12.8	0.0	0.0	12.9
0.5	8.3	0.1	0.0	0.1	0.1	12.8	0.0	0.0	12.9
0.1	1.7	0.0	0.0	0.0	0.0	2.6	0.0	0.0	2.6
0.5	8.6	0.1	0.0	0.1	0.1	13.3	0.0	0.0	13.4
0.5	8.6	0.1	0.0	0.1	0.1	13.3	0.0	0.0	13.4
111.9	2001.0	12.4	1.8	23.7	15.4	3091.9	0.2	0.1	3119.3
0.5	9.3	0.1	0.0	0.1	0.1	14.3	0.0	0.0	14.4
0.6	5.9	0.6	0.0	0.1	0.1	992.3	0.1	0.0	1000.6
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
778.40	**9924.20**	**626.67**	**13.28**	**110.28**	**71.40**	**1005143.90**	**57.53**	**23.31**	**1013578.33**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
377.4	12519.9	325.5	16.8	20.0	13.0	31409.7	1.8	0.8	31688.4
170.1	5643.0	146.7	7.6	9.0	5.9	14157.0	0.8	0.4	14282.6
1.6	157.9	1.3	0.1	0.2	0.1	272.5	0.0	0.0	274.9
0.5	16.9	0.4	0.0	0.0	0.0	42.5	0.0	0.0	42.8
0.9	28.2	0.7	0.0	0.0	0.0	70.8	0.0	0.0	71.4
550.44	**18366.03**	**474.70**	**24.53**	**29.19**	**18.98**	**45952.44**	**2.60**	**1.14**	**46360.23**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
0.0	0.1	23.3	0.0	0.3	0.2	4332.8	0.1	0.1	4378.3
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.01	**0.09**	**23.35**	**0.04**	**0.32**	**0.21**	**4332.79**	**0.12**	**0.14**	**4378.33**

1328.85	**28290.32**	**1124.72**	**37.85**	**139.80**	**90.58**	**1055429.13**	**60.25**	**24.59**	**1064316.89**

151.63	3228.00	128.33	4.32	15.95	10.34	120427.17	6.87	2.81	121441.29
3.41	72.54	2.88	0.10	0.36	0.23	2706.23	0.15	0.06	2729.02
403.77	8595.90	341.74	11.50	42.48	27.52	320688.08	18.31	7.47	323388.59
277.70	5911.95	235.04	7.91	29.21	18.93	220557.63	12.59	5.14	222414.94
178.88	3808.31	151.40	5.10	18.82	12.19	142077.00	8.11	3.31	143273.43
313.47	6673.61	265.32	8.93	32.98	21.37	248973.03	14.21	5.80	251069.63
1328.85	**28290.32**	**1124.72**	**37.85**	**139.80**	**90.58**	**1055429.13**	**60.25**	**24.59**	**1064316.89**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
16.7	553.0	14.4	0.7	0.9	0.6	1387.4	0.1	0.0	1399.7
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.1	47.5	4.7	0.1	0.7	0.4	7938.5	0.5	0.2	8005.1
48.2	4813.7	41.0	4.1	4.7	3.0	8305.4	0.5	0.2	8379.1
0.6	5.9	0.6	0.0	0.1	0.1	992.3	0.1	0.0	1000.6
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.6	5.9	0.6	0.0	0.1	0.1	992.3	0.1	0.0	1000.6
0.2	1.5	1.7	0.0	0.1	0.1	335.8	0.0	0.0	341.1
6.5	117.0	0.7	0.1	1.4	0.9	180.8	0.0	0.0	182.4
1.0	17.2	0.1	0.0	0.2	0.1	26.6	0.0	0.0	26.8
12.6	118.9	11.8	0.2	1.7	1.1	19846.3	1.1	0.5	20012.8
45.5	427.9	42.4	0.7	6.0	3.8	71446.7	4.1	1.7	72045.9
1051.7	9889.5	980.7	16.0	137.6	88.9	1651211.9	94.5	38.3	1665061.3
9.3	307.2	8.0	0.4	0.5	0.3	770.8	0.0	0.0	777.6
5.0	501.4	4.3	0.4	0.5	0.3	865.2	0.0	0.0	872.8
593.3	5578.7	553.2	9.0	77.6	50.2	931452.9	53.3	21.6	939265.4
2.4	43.7	0.3	0.0	0.5	0.3	67.5	0.0	0.0	68.1
21.9	206.0	20.4	0.3	2.9	1.9	34400.2	2.0	0.8	34688.8
4.0	398.6	3.4	0.3	0.4	0.3	687.8	0.0	0.0	693.9
2.0	34.9	0.2	0.0	0.4	0.3	54.0	0.0	0.0	54.5
1.2	21.5	0.1	0.0	0.3	0.2	33.2	0.0	0.0	33.5
1.2	21.5	0.1	0.0	0.3	0.2	33.2	0.0	0.0	33.5
0.4	6.6	0.0	0.0	0.1	0.1	10.2	0.0	0.0	10.3
1.3	22.4	0.1	0.0	0.3	0.2	34.6	0.0	0.0	34.9
1.3	22.4	0.1	0.0	0.3	0.2	34.6	0.0	0.0	34.9
167.8	3001.6	18.6	2.7	35.5	23.1	4637.8	0.3	0.1	4679.0
1.0	18.5	0.1	0.0	0.2	0.1	28.6	0.0	0.0	28.9
2.5	23.8	2.4	0.0	0.3	0.2	3969.3	0.2	0.1	4002.6
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2003.23	**26206.92**	**1710.23**	**35.45**	**273.09**	**176.74**	**2739743.82**	**156.81**	**63.54**	**2762734.10**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
679.3	22535.9	585.9	30.2	35.9	23.4	56537.4	3.2	1.4	57039.1
510.3	16929.0	440.1	22.7	27.0	17.6	42471.0	2.4	1.1	42847.9
3.2	315.9	2.7	0.3	0.3	0.2	545.0	0.0	0.0	549.9
2.0	67.7	1.8	0.1	0.1	0.1	169.9	0.0	0.0	171.4
3.4	112.9	2.9	0.2	0.2	0.1	283.1	0.0	0.0	285.7
1198.21	**39961.36**	**1033.35**	**53.38**	**63.54**	**41.30**	**100006.46**	**5.66**	**2.48**	**100893.93**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
0.0	0.3	70.0	0.1	1.0	0.6	12998.4	0.4	0.4	13135.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.03	**0.26**	**70.04**	**0.12**	**0.96**	**0.62**	**12998.36**	**0.36**	**0.42**	**13134.99**

3201.47	**66168.55**	**2813.62**	**88.96**	**337.58**	**218.66**	**2852748.65**	**162.83**	**66.44**	**2876763.02**

365.30	7550.00	321.04	10.15	38.52	24.95	325505.94	18.58	7.58	328246.04
8.21	169.66	7.21	0.23	0.87	0.56	7314.74	0.42	0.17	7376.32
972.76	20105.06	854.91	27.03	102.57	66.44	866796.70	49.48	20.19	874093.38
669.03	13827.53	587.97	18.59	70.55	45.69	596151.32	34.03	13.88	601169.71
430.97	8907.30	378.76	11.97	45.44	29.44	384023.86	21.92	8.94	387256.56
755.22	15608.99	663.73	20.98	79.64	51.58	672956.09	38.41	15.67	678621.02
3201.47	**66168.55**	**2813.62**	**88.96**	**337.58**	**218.66**	**2852748.65**	**162.83**	**66.44**	**2876763.02**

Santa Clara County Vector Control District Vehicles and Equipments

Land Surveillance and Applications/Management	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
Dodge ¾ ton (1)	5.9 L V8	50%	5%		20%	25%		100%	Gasoline
Dodge Dakota Pickup truck(1)	3.7 L V6	50%	5%		20%	25%		100%	Gasoline
Ford Escape (1)	2.4 L Hybrid	50%	5%		20%	25%		100%	Gasoline
Ford Expedition	4.6 L	50%	5%		20%	25%		100%	Gasoline
Ford F150 (14)	4.6 L V8	50%	5%		20%	25%		100%	Gasoline
Ford F250 (10)	5.4 L V8	50%	5%		20%	25%		100%	Gasoline
Ford Personnel Van(1)	2.4 L 4cyl	50%	5%		20%	25%		100%	Gasoline
Ford Ranger (5)	4.0 L V6	50%	5%		20%	25%		100%	Gasoline
Fork Lift (1)	Battery	50%	5%		20%	25%		100%	Zero
GMC ½ ton (5)	5.3 L V8	50%	5%		20%	25%		100%	Gasoline
International flatbed truck	5.6 L	50%	5%		20%	25%		100%	Diesel

Water Surveillance and Applications/Management	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
Argo Avenger ATV(2)	26 HP Kohler engine	50%				50%		100%	Gasoline
Argo Conquest	20 HP Kawasaki	50%				50%		100%	Gasoline
Boat	Battery	50%				50%		100%	Zero
Kabota	3 cyl 21HP	50%			15%	35%		100%	Diesel
Maruyama Spreader	25 cc 2 stroke	50%				50%		100%	50:1 gas/oil mix
Yamaha Quads (2)	400cc 4 stroke	50%				50%		100%	Gasoline

Aerial Applications	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
Alpine Helicopter Services	Alison C20 Gas Turbine					100%		100%	Jet A

	100.00%	47%	3%	0%	13%	37%	0%	1800%

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Onroad LD				LD	1		60	60	10		120
Onroad LD				LD	1	30	30	30	30		60
Onroad LD				LD	1	20	20	20	20		30
Onroad LD				LD	1	45	45	45	45		30
Onroad LD				LD	14	60	60	60	60		90
Onroad LD				LD	10	60	60	60	60		90
Onroad LD				LD	1	30	30	30	30		30
Onroad LD				LD	5	25	60	60	15		180
Electric				0	1	10	10	10	10	1	
Onroad LD				LD	5	5	30	30	5		60
Onroad MD				MD	1	3	2	2	3		30

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Sport				26	2	13.20	13.20	13.20	13.20	0.12	
Sport	382	23.3	0.86	20.0	1	8.25	8.25	8.25	8.25	0.13	
Electric				0	1	0.51	0.51	0.51	0.51	0.01	
Offroad				21	1	3.64	3.64	3.64	3.64	0.06	
2-stroke	25	1.5	0.92	1.4	1	0.33	0.33	0.33	0.33	0.01	
Sport	400	24.4	0.86	21.0	2	14.80	14.80	14.80	14.80	0.11	

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Turbine				420	1	1				0.031	

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
	120		7200		15600
	60		1800		7200
	30		600		2400
	30		1350		5400
	1260		75600		302400
	900		54000		216000
	30		900		3600
	900		54000		144000
1		10		40	
	300		9000		21000
	30		90		300

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
0.23		3.04		12.14	
0.13		1.07		4.29	
0.01		0.00		0.02	
0.06		0.22		0.87	
0.01		0.00		0.01	
0.22		3.26		13.02	

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
0.031		0.031		0.031	

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00190	0.01284	0.01425	0.00003	0.00055	0.00046	2.79845	0.00009	0.00014	2.84273

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.14742	4.89060	0.12714	0.00655	0.00780	0.00507	12.26940	0.00069	0.00030	12.37828
0.11340	3.76200	0.09780	0.00504	0.00600	0.00390	9.43800	0.00053	0.00023	9.52175
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.01864	0.13672	0.13672	0.00016	0.01657	0.01409	16.43040	0.00094	0.00041	16.57820
0.05179	0.92641	0.00575	0.00083	0.01096	0.00712	1.43143	0.00008	0.00004	1.44413
0.11907	3.95010	0.10269	0.00529	0.00630	0.00410	9.90990	0.00056	0.00025	9.99784

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.00136	0.01094	2.91816	0.00515	0.03979	0.02587	541.59840	0.01497	0.01735	547.29131

Surveillance	47%
Physical Control	3%
Vegetation Management	0%
Biological Control	13%
Chemical Control	37%
Other Non-Chemical	0%
CHECKSUM	**100%**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
0.08	0.79	0.08	0.00	0.01	0.01	132.31	0.01	0.00	133.42
0.04	0.40	0.04	0.00	0.01	0.00	66.15	0.00	0.00	66.71
0.02	0.20	0.02	0.00	0.00	0.00	33.08	0.00	0.00	33.35
0.02	0.20	0.02	0.00	0.00	0.00	33.08	0.00	0.00	33.35
0.88	8.32	0.83	0.01	0.12	0.07	1389.24	0.08	0.03	1400.89
0.63	5.94	0.59	0.01	0.08	0.05	992.31	0.06	0.02	1000.64
0.02	0.20	0.02	0.00	0.00	0.00	33.08	0.00	0.00	33.35
0.63	5.94	0.59	0.01	0.08	0.05	992.31	0.06	0.02	1000.64
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.21	1.98	0.20	0.00	0.03	0.02	330.77	0.02	0.01	333.55
0.06	0.39	0.43	0.00	0.02	0.01	83.95	0.00	0.00	85.28
2.61	**24.36**	**2.80**	**0.04**	**0.35**	**0.23**	**4086.29**	**0.23**	**0.10**	**4121.19**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
0.03	1.12	0.03	0.00	0.00	0.00	2.82	0.00	0.00	2.85
0.01	0.49	0.01	0.00	0.00	0.00	1.23	0.00	0.00	1.24
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.01	0.01	0.00	0.00	0.00	0.99	0.00	0.00	0.99
0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01
0.03	0.87	0.02	0.00	0.00	0.00	2.18	0.00	0.00	2.20
0.08	**2.50**	**0.07**	**0.00**	**0.01**	**0.00**	**7.22**	**0.00**	**0.00**	**7.29**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
0.00	0.00	0.09	0.00	0.00	0.00	16.79	0.00	0.00	16.97
0.00	**0.00**	**0.09**	**0.00**	**0.00**	**0.00**	**16.79**	**0.00**	**0.00**	**16.97**

2.68	**26.85**	**2.97**	**0.04**	**0.36**	**0.23**	**4110.30**	**0.23**	**0.10**	**4145.44**

1.27	12.68	1.40	0.02	0.17	0.11	1940.98	0.11	0.05	1957.57
0.08	0.82	0.09	0.00	0.01	0.01	125.59	0.01	0.00	126.67
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.35	3.51	0.39	0.01	0.05	0.03	536.62	0.03	0.01	541.21
0.98	9.85	1.09	0.02	0.13	0.09	1507.11	0.09	0.04	1519.99
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2.68	**26.85**	**2.97**	**0.04**	**0.36**	**0.23**	**4110.30**	**0.23**	**0.10**	**4145.44**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
5.1	47.5	4.7	0.1	0.7	0.4	7938.5	0.5	0.2	8005.1
1.3	11.9	1.2	0.0	0.2	0.1	1984.6	0.1	0.0	2001.3
0.4	4.0	0.4	0.0	0.1	0.0	661.5	0.0	0.0	667.1
0.9	8.9	0.9	0.0	0.1	0.1	1488.5	0.1	0.0	1501.0
53.1	499.2	49.5	0.8	6.9	4.5	83354.4	4.8	1.9	84053.6
37.9	356.6	35.4	0.6	5.0	3.2	59538.9	3.4	1.4	60038.3
0.6	5.9	0.6	0.0	0.1	0.1	992.3	0.1	0.0	1000.6
37.9	356.6	35.4	0.6	5.0	3.2	59538.9	3.4	1.4	60038.3
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.3	59.4	5.9	0.1	0.8	0.5	9923.1	0.6	0.2	10006.4
0.2	1.2	1.3	0.0	0.0	0.0	251.9	0.0	0.0	255.8
143.75	**1351.25**	**135.17**	**2.19**	**18.83**	**12.18**	**225672.72**	**12.91**	**5.24**	**227567.40**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
0.4	14.8	0.4	0.0	0.0	0.0	37.2	0.0	0.0	37.6
0.1	4.0	0.1	0.0	0.0	0.0	10.1	0.0	0.0	10.2
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	3.6	0.0	0.0	3.6
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.4	12.9	0.3	0.0	0.0	0.0	32.3	0.0	0.0	32.6
0.96	**31.78**	**0.86**	**0.04**	**0.05**	**0.04**	**83.23**	**0.00**	**0.00**	**83.97**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
0.0	0.0	0.1	0.0	0.0	0.0	16.8	0.0	0.0	17.0
0.00	**0.00**	**0.09**	**0.00**	**0.00**	**0.00**	**16.79**	**0.00**	**0.00**	**16.97**

144.71	**1383.02**	**136.11**	**2.23**	**18.88**	**12.22**	**225772.73**	**12.92**	**5.24**	**227668.34**

68.34	653.09	64.27	1.05	8.92	5.77	106614.90	6.10	2.47	107510.05
4.42	42.26	4.16	0.07	0.58	0.37	6898.61	0.39	0.16	6956.53
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18.89	180.56	17.77	0.29	2.47	1.60	29475.88	1.69	0.68	29723.37
53.06	507.11	49.91	0.82	6.92	4.48	82783.34	4.74	1.92	83478.39
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
144.71	**1383.02**	**136.11**	**2.23**	**18.88**	**12.22**	**225772.73**	**12.92**	**5.24**	**227668.34**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
11.0	103.0	10.2	0.2	1.4	0.9	17200.1	1.0	0.4	17344.4
5.1	47.5	4.7	0.1	0.7	0.4	7938.5	0.5	0.2	8005.1
1.7	15.8	1.6	0.0	0.2	0.1	2646.2	0.2	0.1	2668.4
3.8	35.7	3.5	0.1	0.5	0.3	5953.9	0.3	0.1	6003.8
212.4	1996.9	198.0	3.2	27.8	18.0	333417.8	19.1	7.7	336214.3
151.7	1426.4	141.4	2.3	19.8	12.8	238155.6	13.6	5.5	240153.1
2.5	23.8	2.4	0.0	0.3	0.2	3969.3	0.2	0.1	4002.6
101.1	950.9	94.3	1.5	13.2	8.6	158770.4	9.1	3.7	160102.1
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.7	138.7	13.8	0.2	1.9	1.2	23154.0	1.3	0.5	23348.2
0.6	3.9	4.3	0.0	0.2	0.1	839.5	0.0	0.0	852.8
504.52	**4742.55**	**474.19**	**7.68**	**66.08**	**42.75**	**792045.24**	**45.32**	**18.38**	**798694.71**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
1.8	59.4	1.5	0.1	0.1	0.1	149.0	0.0	0.0	150.3
0.5	16.1	0.4	0.0	0.0	0.0	40.5	0.0	0.0	40.8
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.1	0.1	0.0	0.0	0.0	14.4	0.0	0.0	14.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.6	51.4	1.3	0.1	0.1	0.1	129.1	0.0	0.0	130.2
3.84	**127.10**	**3.42**	**0.17**	**0.22**	**0.14**	**332.92**	**0.02**	**0.01**	**335.87**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
0.0	0.0	0.1	0.0	0.0	0.0	16.8	0.0	0.0	17.0
0.00	**0.00**	**0.09**	**0.00**	**0.00**	**0.00**	**16.79**	**0.00**	**0.00**	**16.97**

508.37	**4869.65**	**477.70**	**7.85**	**66.29**	**42.90**	**792394.94**	**45.34**	**18.39**	**799047.55**

240.06	2299.56	225.58	3.71	31.31	20.26	374186.50	21.41	8.68	377328.01
15.53	148.79	14.60	0.24	2.03	1.31	24212.07	1.39	0.56	24415.34
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
66.37	635.76	62.37	1.03	8.66	5.60	103451.56	5.92	2.40	104320.10
186.40	1785.54	175.16	2.88	24.31	15.73	290544.81	16.62	6.74	292984.10
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
508.37	**4869.65**	**477.70**	**7.85**	**66.29**	**42.90**	**792394.94**	**45.34**	**18.39**	**799047.55**

Solano County Mosquito Abatement District Vehicles and Equipments

Land Surveillance and Applications/Management	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
Chevrolet Astro Van	4.3L						100%	100%	Gasoline
Clark Forklift	Nissan 4 cylinder						100%	100%	LPG
Colt handheld ULV Fogger x 6	Tecumseh TCII					100%		100%	50:1 gas/oil mix
Craftsman 24" Leaf Vac	Briggs 190cc						100%	100%	Gasoline
Ford Pickup Truck	6.8L					100%		100%	Gasoline
Ford Pickup Truck x6	4.6L & 6.2L	80%			1%	19%		100%	Gasoline
Kubota Tractor	27hp						100%	100%	Diesel
Leco 500 ULV Fogger x2	Briggs 5.5hp					100%		100%	Gasoline
London Fog M.A.G. ULV Fogger x3	Briggs 3hp					100%		100%	Gasoline
Maruyama MD155DX Backpack Sprayer x 5	Kawasaki 40.2cc					100%		100%	50:1 gas/oil mix
Pro-Mist 25HD	Electric					100%		100%	Zero
Snapper Rear Engine Riding Mower	Briggs 12.5hp						100%	100%	Gasoline
Stihl 025 Chainsaw	44cc						100%	100%	50:1 gas/oil mix
Stihl BG55 Leaf Blower	27cc						100%	100%	50:1 gas/oil mix
Stihl FS83 Weedeater	25.4 cc						100%	100%	50:1 gas/oil mix
Stihl HS Hedge trimmer	25.4 cc						100%	100%	50:1 gas/oil mix
Toro Push Mower	Kawasaki 6.5hp						100%	100%	Gasoline

Water Surveillance and Applications/Management	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
Achilles Inflatable boat	Electric	100%						100%	Zero
Argo ATV Avenger	Koehler Aegis 25	90%				10%		100%	Gasoline
Argo ATV Avenger x2	Koehler Aegis 26	90%				10%		100%	Gasoline
Argo ATV Conquest x4	Kawasaki FD620	90%				10%		100%	Gasoline
Argo ATV Mangnum	Koehler 18hp	100%						100%	Gasoline
Honda ATV TRX300FW x2	300cc	100%						100%	Gasoline
Honda ATV TRX350FM	350cc	15%				85%		100%	Gasoline
Honda ATV TRX400FE	400cc	15%				85%		100%	Gasoline
Honda ATV TRX500FM	500cc	15%				85%		100%	Gasoline
Invader boat 19'	Mercury 90hp	100%						100%	Gasoline

Aerial Applications	Engine/Motor	Sur-veil	Phys Cntl	Veg Mgt	Bio Cntl	Chem Cntl	Non Chem	ALL ALTS	Petro Fuel
1960 Hiller Soloy helicopter (Alpine) 120 gal material tank	Allison 250-C20J turboshaft, 420 shp					100%		100%	Jet A
1968 Bell 206 Jet Ranger helicopter (Alpine) 120 gal material tank	Allison 250-C20J turboshaft, 420 shp					100%		100%	Jet A
1989 Bell 206 Jet Ranger helicopter (Alpine) 120 gal material tank	Allison 250-C20J turboshaft, 420 shp					100%		100%	Jet A
1992 Air Tractor AT-502 Turbine (PT6A series turboprop)	507 kW (680shp) Pratt & Whitney Canada					100%		100%	Jet A
Isolair 4400 bucket system (helicopter-mounted)	N/A					100%		100%	Zero
Isolair Air spray system model 3900 (helicopter-mounted)	N/A					100%		100%	Zero

100.00%	24%	0%	0%	0%	46%	30%	3300%	

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Onroad LD				LD	1	60	60	60	50		30
Propane	2700	164.8	0.56	92.0	1	5	5	5	5	0.5	
2-stroke	49	3.0	0.92	2.8	6	0	10	4	0	0.5	
Utility	190	11.6	0.56	6.5	1	1	0	0	1	1	
Onroad LD				LD	1	0	10	2	8		60
Onroad LD				LD	6	50	60	60	50		120
Offroad	790	48.2	0.56	27.0	1	5	5	5	5	1	
Utility	160	9.8	0.56	5.5	2	0	5	2	8	2	
Utility	88	5.4	0.56	3.0	3	0	15	15	5	2	
2-stroke	40	2.4	0.92	2.2	5	5	10	10	0	1	
Electric				0	1	0	10	2	8	1	
Utility	366	22.3	0.56	13.0	1	10	10	10	10	1	
2-stroke	44	2.7	0.92	2.5	1	1	1	0	0	0.1	
2-stroke	27	1.6	0.92	1.5	1	10	15	15	10	1	
2-stroke	25	1.5	0.92	1.4	1	10	15	15	10	0.5	
2-stroke	25	1.5	0.92	1.4	1	0	2	2	0	1	
Utility	190	11.6	0.56	6.5	1	5	5	5	5	1	

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Electric				0	1	0	0	2	0	2	
Sport	476	29.0	0.86	25.0	1	15	10	6	10	3	
Sport	495	30.2	0.86	26.0	2	4	8	8	20	4	
Sport	620	37.8	0.86	33.0	4	0	0	5	15	4	
Sport	343	20.9	0.86	18.0	1	0	0	0	2	2	
Sport	300	18.3	0.86	16.0	2	0	2	2	0	1	
Sport	350	21.4	0.86	18.0	1	0	15	15	0	3	
Sport	400	24.4	0.86	21.0	1	0	6	6	0	2	
Sport	500	30.5	0.86	26.0	1	0	8	8	0	3	
Sport	1715	104.7	0.86	90.0	1	0	0	4	0	2	

Engine/Motor Type			Power Output		Quantity	Winter	Spring	Summer	Fall	Activity Schedule	
category	ccd	cid	BHP/cid	BHP		days	days	days	days	hrs/day	mi/day
Turbine				420	1	2	0	0	0	2	
Turbine				420	1	2	0	0	0	2	
Turbine				420	1	2	0	0	0	2	
Turbine				680	1	4	6	10	14	4	
None				0	1	2	0	0	0	1	
None				0	1	6	0	0	0	2	

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
	30		1800		6900
0.5		2.5		10	
3		30		42	
1		1		2	
	60		600		1200
	720		43200		158400
1		5		20	
4		32		60	
6		90		210	
5		50		125	
1		10		20	
1		10		40	
0.1		0.1		0.2	
1		15		50	
0.5		7.5		25	
1		2		4	
1		5		20	

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
2		4		4	
3		45		123	
8		160		320	
16		240		320	
2		4		4	
2		4		8	
3		45		90	
2		12		24	
3		24		48	
2		8		8	

Peak Daily		Highest Quarter		Annual Total	
hours	miles	hours	miles	hours	miles
2		4		4	
2		4		4	
2		4		4	
4		56		136	
1		2		2	
2		12		12	

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.73030	0.30746	0.46754	0.00033	0.00552	0.00359	75.73440	0.00006	0.00017	75.78690
0.10357	1.85281	0.01151	0.00167	0.02191	0.01424	2.86286	0.00016	0.00007	2.88827
0.03260	3.25927	0.02777	0.00279	0.00315	0.00205	5.62348	0.00032	0.00014	5.67338
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
0.02397	0.14648	0.17578	0.00018	0.01598	0.01358	18.48420	0.00105	0.00046	18.65048
0.02759	2.75785	0.02350	0.00236	0.00267	0.00173	4.75833	0.00027	0.00012	4.80055
0.01505	1.50428	0.01282	0.00129	0.00146	0.00095	2.59545	0.00015	0.00006	2.61848
0.08138	1.45578	0.00904	0.00131	0.01722	0.01119	2.24939	0.00013	0.00006	2.26935
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.12285	4.07550	0.10595	0.00546	0.00650	0.00423	10.22450	0.00058	0.00025	10.31523
0.09248	1.65430	0.01028	0.00149	0.01957	0.01272	2.55613	0.00014	0.00006	2.57881
0.05549	0.99258	0.00617	0.00089	0.01174	0.00763	1.53368	0.00009	0.00004	1.54729
0.05179	0.92641	0.00575	0.00083	0.01096	0.00712	1.43143	0.00008	0.00004	1.44413
0.05179	0.92641	0.00575	0.00083	0.01096	0.00712	1.43143	0.00008	0.00004	1.44413
0.03260	3.25927	0.02777	0.00279	0.00315	0.00205	5.62348	0.00032	0.00014	5.67338

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.14175	4.70250	0.12225	0.00630	0.00750	0.00488	11.79750	0.00067	0.00029	11.90219
0.14742	4.89060	0.12714	0.00655	0.00780	0.00507	12.26940	0.00069	0.00030	12.37828
0.18711	6.20730	0.16137	0.00832	0.00990	0.00644	15.57270	0.00088	0.00039	15.71089
0.10206	3.38580	0.08802	0.00454	0.00540	0.00351	8.49420	0.00048	0.00021	8.56958
0.09072	3.00960	0.07824	0.00403	0.00480	0.00312	7.55040	0.00043	0.00019	7.61740
0.10206	3.38580	0.08802	0.00454	0.00540	0.00351	8.49420	0.00048	0.00021	8.56958
0.11907	3.95010	0.10269	0.00529	0.00630	0.00410	9.90990	0.00056	0.00025	9.99784
0.14742	4.89060	0.12714	0.00655	0.00780	0.00507	12.26940	0.00069	0.00030	12.37828
0.51030	16.92900	0.44010	0.02268	0.02700	0.01755	42.47100	0.00240	0.00105	42.84789

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
0.00136	0.01094	2.91816	0.00515	0.03979	0.02587	541.59840	0.01497	0.01735	547.29131
0.00136	0.01094	2.91816	0.00515	0.03979	0.02587	541.59840	0.01497	0.01735	547.29131
0.00136	0.01094	2.91816	0.00515	0.03979	0.02587	541.59840	0.01497	0.01735	547.29131
0.00220	0.01772	4.72464	0.00835	0.06443	0.04188	876.87360	0.02424	0.02809	886.09069
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Surveillance	24%
Physical Control	0%
Vegetation Management	0%
Biological Control	0%
Chemical Control	46%
Other Non-Chemical	30%
CHECKSUM	**100%**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
0.02	0.20	0.02	0.00	0.00	0.00	33.08	0.00	0.00	33.35
0.37	0.15	0.23	0.00	0.00	0.00	37.87	0.00	0.00	37.89
0.31	5.56	0.03	0.01	0.07	0.04	8.59	0.00	0.00	8.66
0.03	3.26	0.03	0.00	0.00	0.00	5.62	0.00	0.00	5.67
0.04	0.40	0.04	0.00	0.01	0.00	66.15	0.00	0.00	66.71
0.51	4.75	0.47	0.01	0.07	0.04	793.85	0.05	0.02	800.51
0.02	0.15	0.18	0.00	0.02	0.01	18.48	0.00	0.00	18.65
0.11	11.03	0.09	0.01	0.01	0.01	19.03	0.00	0.00	19.20
0.09	9.03	0.08	0.01	0.01	0.01	15.57	0.00	0.00	15.71
0.41	7.28	0.05	0.01	0.09	0.06	11.25	0.00	0.00	11.35
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.12	4.08	0.11	0.01	0.01	0.00	10.22	0.00	0.00	10.32
0.01	0.17	0.00	0.00	0.00	0.00	0.26	0.00	0.00	0.26
0.06	0.99	0.01	0.00	0.01	0.01	1.53	0.00	0.00	1.55
0.03	0.46	0.00	0.00	0.01	0.00	0.72	0.00	0.00	0.72
0.05	0.93	0.01	0.00	0.01	0.01	1.43	0.00	0.00	1.44
0.03	3.26	0.03	0.00	0.00	0.00	5.62	0.00	0.00	5.67
2.21	**51.69**	**1.37**	**0.05**	**0.31**	**0.20**	**1029.28**	**0.06**	**0.02**	**1037.68**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.43	14.11	0.37	0.02	0.02	0.01	35.39	0.00	0.00	35.71
1.18	39.12	1.02	0.05	0.06	0.04	98.16	0.01	0.00	99.03
2.99	99.32	2.58	0.13	0.16	0.10	249.16	0.01	0.01	251.37
0.20	6.77	0.18	0.01	0.01	0.01	16.99	0.00	0.00	17.14
0.18	6.02	0.16	0.01	0.01	0.01	15.10	0.00	0.00	15.23
0.31	10.16	0.26	0.01	0.02	0.01	25.48	0.00	0.00	25.71
0.24	7.90	0.21	0.01	0.01	0.01	19.82	0.00	0.00	20.00
0.44	14.67	0.38	0.02	0.02	0.02	36.81	0.00	0.00	37.13
1.02	33.86	0.88	0.05	0.05	0.04	84.94	0.00	0.00	85.70
6.99	**231.93**	**6.03**	**0.31**	**0.37**	**0.24**	**581.85**	**0.03**	**0.01**	**587.02**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day	lbs/day
0.00	0.02	5.84	0.01	0.08	0.05	1083.20	0.03	0.03	1094.58
0.00	0.02	5.84	0.01	0.08	0.05	1083.20	0.03	0.03	1094.58
0.00	0.02	5.84	0.01	0.08	0.05	1083.20	0.03	0.03	1094.58
0.01	0.07	18.90	0.03	0.26	0.17	3507.49	0.10	0.11	3544.36
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.02	**0.14**	**36.41**	**0.06**	**0.50**	**0.32**	**6757.08**	**0.19**	**0.22**	**6828.11**

9.21	**283.75**	**43.80**	**0.43**	**1.17**	**0.77**	**8368.22**	**0.28**	**0.25**	**8452.80**

2.22	68.36	10.55	0.10	0.28	0.18	2015.98	0.07	0.06	2036.36
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.09	0.01	0.00	0.00	0.00	2.54	0.00	0.00	2.56
4.20	129.32	19.96	0.19	0.53	0.35	3813.88	0.13	0.12	3852.43
2.79	85.98	13.27	0.13	0.36	0.23	2535.82	0.08	0.08	2561.46
9.21	**283.75**	**43.80**	**0.43**	**1.17**	**0.77**	**8368.22**	**0.28**	**0.25**	**8452.80**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
1.3	11.9	1.2	0.0	0.2	0.1	1984.6	0.1	0.0	2001.3
1.8	0.8	1.2	0.0	0.0	0.0	189.3	0.0	0.0	189.5
3.1	55.6	0.3	0.1	0.7	0.4	85.9	0.0	0.0	86.6
0.0	3.3	0.0	0.0	0.0	0.0	5.6	0.0	0.0	5.7
0.4	4.0	0.4	0.0	0.1	0.0	661.5	0.0	0.0	667.1
30.3	285.3	28.3	0.5	4.0	2.6	47631.1	2.7	1.1	48030.6
0.1	0.7	0.9	0.0	0.1	0.1	92.4	0.0	0.0	93.3
0.9	88.3	0.8	0.1	0.1	0.1	152.3	0.0	0.0	153.6
1.4	135.4	1.2	0.1	0.1	0.1	233.6	0.0	0.0	235.7
4.1	72.8	0.5	0.1	0.9	0.6	112.5	0.0	0.0	113.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.2	40.8	1.1	0.1	0.1	0.0	102.2	0.0	0.0	103.2
0.0	0.2	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.3
0.8	14.9	0.1	0.0	0.2	0.1	23.0	0.0	0.0	23.2
0.4	6.9	0.0	0.0	0.1	0.1	10.7	0.0	0.0	10.8
0.1	1.9	0.0	0.0	0.0	0.0	2.9	0.0	0.0	2.9
0.2	16.3	0.1	0.0	0.0	0.0	28.1	0.0	0.0	28.4
46.14	**738.80**	**35.99**	**0.89**	**6.38**	**4.15**	**51316.10**	**2.93**	**1.19**	**51745.48**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.4	211.6	5.5	0.3	0.3	0.2	530.9	0.0	0.0	535.6
23.6	782.5	20.3	1.0	1.2	0.8	1963.1	0.1	0.0	1980.5
44.9	1489.8	38.7	2.0	2.4	1.5	3737.4	0.2	0.1	3770.6
0.4	13.5	0.4	0.0	0.0	0.0	34.0	0.0	0.0	34.3
0.4	12.0	0.3	0.0	0.0	0.0	30.2	0.0	0.0	30.5
4.6	152.4	4.0	0.2	0.2	0.2	382.2	0.0	0.0	385.6
1.4	47.4	1.2	0.1	0.1	0.0	118.9	0.0	0.0	120.0
3.5	117.4	3.1	0.2	0.2	0.1	294.5	0.0	0.0	297.1
4.1	135.4	3.5	0.2	0.2	0.1	339.8	0.0	0.0	342.8
89.29	**2962.01**	**77.00**	**3.97**	**4.72**	**3.07**	**7431.01**	**0.42**	**0.18**	**7496.95**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr	lbs/qtr
0.0	0.0	11.7	0.0	0.2	0.1	2166.4	0.1	0.1	2189.2
0.0	0.0	11.7	0.0	0.2	0.1	2166.4	0.1	0.1	2189.2
0.0	0.0	11.7	0.0	0.2	0.1	2166.4	0.1	0.1	2189.2
0.1	1.0	264.6	0.5	3.6	2.3	49104.9	1.4	1.6	49621.1
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.14	**1.12**	**299.60**	**0.53**	**4.09**	**2.66**	**55604.10**	**1.54**	**1.78**	**56188.57**

135.57	**3701.93**	**412.59**	**5.39**	**15.19**	**9.88**	**114351.21**	**4.88**	**3.15**	**115431.01**

32.66	891.83	99.40	1.30	3.66	2.38	27548.25	1.18	0.76	27808.38
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.04	1.12	0.13	0.00	0.00	0.00	34.65	0.00	0.00	34.98
61.78	1687.18	188.04	2.46	6.92	4.50	52116.43	2.23	1.44	52608.56
41.08	1121.80	125.03	1.63	4.60	2.99	34651.88	1.48	0.96	34979.09
135.57	**3701.93**	**412.59**	**5.39**	**15.19**	**9.88**	**114351.21**	**4.88**	**3.15**	**115431.01**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
4.8	45.6	4.5	0.1	0.6	0.4	7607.7	0.4	0.2	7671.6
7.3	3.1	4.7	0.0	0.1	0.0	757.3	0.0	0.0	757.9
4.4	77.8	0.5	0.1	0.9	0.6	120.2	0.0	0.0	121.3
0.1	6.5	0.1	0.0	0.0	0.0	11.2	0.0	0.0	11.3
0.8	7.9	0.8	0.0	0.1	0.1	1323.1	0.1	0.0	1334.2
111.2	1046.0	103.7	1.7	14.5	9.4	174647.4	10.0	4.0	176112.3
0.5	2.9	3.5	0.0	0.3	0.3	369.7	0.0	0.0	373.0
1.7	165.5	1.4	0.1	0.2	0.1	285.5	0.0	0.0	288.0
3.2	315.9	2.7	0.3	0.3	0.2	545.0	0.0	0.0	549.9
10.2	182.0	1.1	0.2	2.2	1.4	281.2	0.0	0.0	283.7
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.9	163.0	4.2	0.2	0.3	0.2	409.0	0.0	0.0	412.6
0.0	0.3	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.5
2.8	49.6	0.3	0.0	0.6	0.4	76.7	0.0	0.0	77.4
1.3	23.2	0.1	0.0	0.3	0.2	35.8	0.0	0.0	36.1
0.2	3.7	0.0	0.0	0.0	0.0	5.7	0.0	0.0	5.8
0.7	65.2	0.6	0.1	0.1	0.0	112.5	0.0	0.0	113.5
153.97	**2158.20**	**128.26**	**2.78**	**20.44**	**13.30**	**186588.63**	**10.64**	**4.31**	**188148.95**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17.4	578.4	15.0	0.8	0.9	0.6	1451.1	0.1	0.0	1464.0
47.2	1565.0	40.7	2.1	2.5	1.6	3926.2	0.2	0.1	3961.0
59.9	1986.3	51.6	2.7	3.2	2.1	4983.3	0.3	0.1	5027.5
0.4	13.5	0.4	0.0	0.0	0.0	34.0	0.0	0.0	34.3
0.7	24.1	0.6	0.0	0.0	0.0	60.4	0.0	0.0	60.9
9.2	304.7	7.9	0.4	0.5	0.3	764.5	0.0	0.0	771.3
2.9	94.8	2.5	0.1	0.2	0.1	237.8	0.0	0.0	239.9
7.1	234.7	6.1	0.3	0.4	0.2	588.9	0.0	0.0	594.2
4.1	135.4	3.5	0.2	0.2	0.1	339.8	0.0	0.0	342.8
148.82	**4937.06**	**128.35**	**6.61**	**7.87**	**5.12**	**12385.96**	**0.70**	**0.31**	**12495.87**

VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr	lbs/yr
0.0	0.0	11.7	0.0	0.2	0.1	2166.4	0.1	0.1	2189.2
0.0	0.0	11.7	0.0	0.2	0.1	2166.4	0.1	0.1	2189.2
0.0	0.0	11.7	0.0	0.2	0.1	2166.4	0.1	0.1	2189.2
0.3	2.4	642.6	1.1	8.8	5.7	119254.8	3.3	3.8	120508.3
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.32	**2.54**	**677.57**	**1.20**	**9.24**	**6.01**	**125753.99**	**3.48**	**4.03**	**127075.83**

303.11	**7097.80**	**934.18**	**10.59**	**37.56**	**24.42**	**324728.58**	**14.81**	**8.65**	**327720.65**

73.02	1709.93	225.05	2.55	9.05	5.88	78230.07	3.57	2.08	78950.88
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.09	2.15	0.28	0.00	0.01	0.01	98.40	0.00	0.00	99.31
138.15	3234.88	425.76	4.83	17.12	11.13	147997.51	6.75	3.94	149361.17
91.85	2150.85	283.09	3.21	11.38	7.40	98402.60	4.49	2.62	99309.29
303.11	**7097.80**	**934.18**	**10.59**	**37.56**	**24.42**	**324728.58**	**14.81**	**8.65**	**327720.65**

Emission Factors for Onroad Vehicles, Offroad Equipments, Vessels, Aircrafts												
Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
50:1 gas/oil mix	2-stroke	0.1	0.00370	0.06617	0.00041	0.00006	0.00078	0.00051	0.11011	0.00001	0.00000	0.11109
50:1 gas/oil mix	2-stroke	0.2	0.00740	0.13234	0.00082	0.00012	0.00157	0.00102	0.22022	0.00001	0.00001	0.22217
50:1 gas/oil mix	2-stroke	0.3	0.01110	0.19852	0.00123	0.00018	0.00235	0.00153	0.33033	0.00002	0.00001	0.33326
50:1 gas/oil mix	2-stroke	0.4	0.01480	0.26469	0.00164	0.00024	0.00313	0.00203	0.44044	0.00002	0.00001	0.44435
50:1 gas/oil mix	2-stroke	0.5	0.01850	0.33086	0.00206	0.00030	0.00391	0.00254	0.55055	0.00003	0.00001	0.55544
50:1 gas/oil mix	2-stroke	0.6	0.02219	0.39703	0.00247	0.00036	0.00470	0.00305	0.66066	0.00004	0.00002	0.66652
50:1 gas/oil mix	2-stroke	0.7	0.02589	0.46320	0.00288	0.00042	0.00548	0.00356	0.77077	0.00004	0.00002	0.77761
50:1 gas/oil mix	2-stroke	0.8	0.02959	0.52938	0.00329	0.00048	0.00626	0.00407	0.88088	0.00005	0.00002	0.88870
50:1 gas/oil mix	2-stroke	0.9	0.03329	0.59555	0.00370	0.00054	0.00704	0.00458	0.99099	0.00006	0.00002	0.99978
50:1 gas/oil mix	2-stroke	1.0	0.03699	0.66172	0.00411	0.00060	0.00783	0.00509	1.02245	0.00006	0.00003	1.03152
50:1 gas/oil mix	2-stroke	1.1	0.04069	0.72789	0.00452	0.00065	0.00861	0.00560	1.12470	0.00006	0.00003	1.13468
50:1 gas/oil mix	2-stroke	1.2	0.04439	0.79406	0.00493	0.00071	0.00939	0.00610	1.22694	0.00007	0.00003	1.23783
50:1 gas/oil mix	2-stroke	1.3	0.04809	0.86023	0.00534	0.00077	0.01017	0.00661	1.32919	0.00008	0.00003	1.34098
50:1 gas/oil mix	2-stroke	1.4	0.05179	0.92641	0.00575	0.00083	0.01096	0.00712	1.43143	0.00008	0.00004	1.44413
50:1 gas/oil mix	2-stroke	1.5	0.05549	0.99258	0.00617	0.00089	0.01174	0.00763	1.53368	0.00009	0.00004	1.54729
50:1 gas/oil mix	2-stroke	1.6	0.05918	1.05875	0.00658	0.00095	0.01252	0.00814	1.63592	0.00009	0.00004	1.65044
50:1 gas/oil mix	2-stroke	1.7	0.06288	1.12492	0.00699	0.00101	0.01330	0.00865	1.73817	0.00010	0.00004	1.75359
50:1 gas/oil mix	2-stroke	1.8	0.06658	1.19109	0.00740	0.00107	0.01409	0.00916	1.84041	0.00010	0.00005	1.85674
50:1 gas/oil mix	2-stroke	1.9	0.07028	1.25727	0.00781	0.00113	0.01487	0.00967	1.94266	0.00011	0.00005	1.95989
50:1 gas/oil mix	2-stroke	2.0	0.07398	1.32344	0.00822	0.00119	0.01565	0.01017	2.04490	0.00012	0.00005	2.06305
50:1 gas/oil mix	2-stroke	2.1	0.07768	1.38961	0.00863	0.00125	0.01644	0.01068	2.14715	0.00012	0.00005	2.16620
50:1 gas/oil mix	2-stroke	2.2	0.08138	1.45578	0.00904	0.00131	0.01722	0.01119	2.24939	0.00013	0.00006	2.26935
50:1 gas/oil mix	2-stroke	2.3	0.08508	1.52195	0.00945	0.00137	0.01800	0.01170	2.35164	0.00013	0.00006	2.37250
50:1 gas/oil mix	2-stroke	2.4	0.08878	1.58813	0.00986	0.00143	0.01878	0.01221	2.45388	0.00014	0.00006	2.47566
50:1 gas/oil mix	2-stroke	2.5	0.09248	1.65430	0.01028	0.00149	0.01957	0.01272	2.55613	0.00014	0.00006	2.57881
50:1 gas/oil mix	2-stroke	2.6	0.09618	1.72047	0.01069	0.00155	0.02035	0.01323	2.65837	0.00015	0.00007	2.68196
50:1 gas/oil mix	2-stroke	2.7	0.09987	1.78664	0.01110	0.00161	0.02113	0.01374	2.76062	0.00016	0.00007	2.78511
50:1 gas/oil mix	2-stroke	2.8	0.10357	1.85281	0.01151	0.00167	0.02191	0.01424	2.86286	0.00016	0.00007	2.88827
50:1 gas/oil mix	2-stroke	2.9	0.10727	1.91899	0.01192	0.00173	0.02270	0.01475	2.96511	0.00017	0.00007	2.99142
50:1 gas/oil mix	2-stroke	3.0	0.15980	1.48702	0.01776	0.00179	0.02348	0.01526	2.83140	0.00016	0.00007	2.85653
50:1 gas/oil mix	2-stroke	3.1	0.16513	1.53659	0.01835	0.00185	0.02426	0.01577	2.92578	0.00017	0.00007	2.95174
50:1 gas/oil mix	2-stroke	3.2	0.17045	1.58615	0.01894	0.00190	0.02504	0.01628	3.02016	0.00017	0.00007	3.04696
50:1 gas/oil mix	2-stroke	3.3	0.17578	1.63572	0.01953	0.00196	0.02583	0.01679	3.11454	0.00018	0.00008	3.14218
50:1 gas/oil mix	2-stroke	3.4	0.18111	1.68529	0.02012	0.00202	0.02661	0.01730	3.20892	0.00018	0.00008	3.23740
50:1 gas/oil mix	2-stroke	3.5	0.18643	1.73485	0.02071	0.00208	0.02739	0.01781	3.30330	0.00019	0.00008	3.33261
50:1 gas/oil mix	2-stroke	3.6	0.19176	1.78442	0.02131	0.00214	0.02818	0.01831	3.39768	0.00019	0.00008	3.42783
50:1 gas/oil mix	2-stroke	3.7	0.19709	1.83399	0.02190	0.00220	0.02896	0.01882	3.49206	0.00020	0.00009	3.52305
50:1 gas/oil mix	2-stroke	3.8	0.20241	1.88356	0.02249	0.00226	0.02974	0.01933	3.58644	0.00020	0.00009	3.61827
50:1 gas/oil mix	2-stroke	3.9	0.20774	1.93312	0.02308	0.00232	0.03052	0.01984	3.68082	0.00021	0.00009	3.71348
50:1 gas/oil mix	2-stroke	4.0	0.21307	1.98269	0.02367	0.00238	0.03131	0.02035	3.77520	0.00021	0.00009	3.80870
50:1 gas/oil mix	2-stroke	4.1	0.21839	2.03226	0.02427	0.00244	0.03209	0.02086	3.86958	0.00022	0.00010	3.90392
50:1 gas/oil mix	2-stroke	4.2	0.22372	2.08183	0.02486	0.00250	0.03287	0.02137	3.96396	0.00022	0.00010	3.99914
50:1 gas/oil mix	2-stroke	4.3	0.22905	2.13139	0.02545	0.00256	0.03365	0.02187	4.05834	0.00023	0.00010	4.09435
50:1 gas/oil mix	2-stroke	4.4	0.23437	2.18096	0.02604	0.00262	0.03444	0.02238	4.15272	0.00023	0.00010	4.18957
50:1 gas/oil mix	2-stroke	4.5	0.23970	2.23053	0.02663	0.00268	0.03522	0.02289	4.24710	0.00024	0.00011	4.28479
50:1 gas/oil mix	2-stroke	4.6	0.24503	2.28009	0.02723	0.00274	0.03600	0.02340	4.34148	0.00025	0.00011	4.38001
50:1 gas/oil mix	2-stroke	4.7	0.25035	2.32966	0.02782	0.00280	0.03678	0.02391	4.43586	0.00025	0.00011	4.47522
50:1 gas/oil mix	2-stroke	4.8	0.25568	2.37923	0.02841	0.00286	0.03757	0.02442	4.53024	0.00026	0.00011	4.57044
50:1 gas/oil mix	2-stroke	4.9	0.26101	2.42880	0.02900	0.00292	0.03835	0.02493	4.62462	0.00026	0.00011	4.66566
50:1 gas/oil mix	2-stroke	5.0	0.26633	2.47836	0.02959	0.00298	0.03913	0.02544	4.71900	0.00027	0.00012	4.76088
50:1 gas/oil mix	2-stroke	5.1	0.27166	2.52793	0.03018	0.00304	0.03991	0.02594	4.81338	0.00027	0.00012	4.85609
50:1 gas/oil mix	2-stroke	5.2	0.27698	2.57750	0.03078	0.00310	0.04070	0.02645	4.90776	0.00028	0.00012	4.95131
50:1 gas/oil mix	2-stroke	5.3	0.28231	2.62707	0.03137	0.00315	0.04148	0.02696	5.00214	0.00028	0.00012	5.04653
50:1 gas/oil mix	2-stroke	5.4	0.28764	2.67663	0.03196	0.00321	0.04226	0.02747	5.09652	0.00029	0.00013	5.14175
50:1 gas/oil mix	2-stroke	5.5	0.29296	2.72620	0.03255	0.00327	0.04305	0.02798	5.19090	0.00029	0.00013	5.23696
50:1 gas/oil mix	2-stroke	5.6	0.29829	2.77577	0.03314	0.00333	0.04383	0.02849	5.28528	0.00030	0.00013	5.33218
50:1 gas/oil mix	2-stroke	5.7	0.30362	2.82533	0.03374	0.00339	0.04461	0.02900	5.37966	0.00030	0.00013	5.42740
50:1 gas/oil mix	2-stroke	5.8	0.30894	2.87490	0.03433	0.00345	0.04539	0.02951	5.47404	0.00031	0.00014	5.52262
50:1 gas/oil mix	2-stroke	5.9	0.31427	2.92447	0.03492	0.00351	0.04618	0.03001	5.56842	0.00032	0.00014	5.61783
50:1 gas/oil mix	2-stroke	6.0	0.31960	2.97404	0.03551	0.00357	0.04696	0.03052	5.66280	0.00032	0.00014	5.71305
50:1 gas/oil mix	2-stroke	6.1	0.32492	3.02360	0.03610	0.00363	0.04774	0.03103	5.75718	0.00033	0.00014	5.80827
50:1 gas/oil mix	2-stroke	6.2	0.33025	3.07317	0.03669	0.00369	0.04852	0.03154	5.85156	0.00033	0.00015	5.90349
50:1 gas/oil mix	2-stroke	6.3	0.33558	3.12274	0.03729	0.00375	0.04931	0.03205	5.94594	0.00034	0.00015	5.99871
50:1 gas/oil mix	2-stroke	6.4	0.34090	3.17231	0.03788	0.00381	0.05009	0.03256	6.04032	0.00034	0.00015	6.09392
50:1 gas/oil mix	2-stroke	6.5	0.34623	3.22187	0.03847	0.00387	0.05087	0.03307	6.13470	0.00035	0.00015	6.18914
50:1 gas/oil mix	2-stroke	6.6	0.35156	3.27144	0.03906	0.00393	0.05165	0.03358	6.22908	0.00035	0.00015	6.28436
50:1 gas/oil mix	2-stroke	6.7	0.35688	3.32101	0.03965	0.00399	0.05244	0.03408	6.32346	0.00036	0.00016	6.37958
50:1 gas/oil mix	2-stroke	6.8	0.36221	3.37057	0.04025	0.00405	0.05322	0.03459	6.41784	0.00036	0.00016	6.47479
50:1 gas/oil mix	2-stroke	6.9	0.36754	3.42014	0.04084	0.00411	0.05400	0.03510	6.51222	0.00037	0.00016	6.57001
50:1 gas/oil mix	2-stroke	7.0	0.37286	3.46971	0.04143	0.00417	0.05479	0.03561	6.60660	0.00037	0.00016	6.66523
50:1 gas/oil mix	2-stroke	7.1	0.37819	3.51928	0.04202	0.00423	0.05557	0.03612	6.70098	0.00038	0.00017	6.76045
50:1 gas/oil mix	2-stroke	7.2	0.38352	3.56884	0.04261	0.00429	0.05635	0.03663	6.79536	0.00038	0.00017	6.85566
50:1 gas/oil mix	2-stroke	7.3	0.38884	3.61841	0.04320	0.00435	0.05713	0.03714	6.88974	0.00039	0.00017	6.95088
50:1 gas/oil mix	2-stroke	7.4	0.39417	3.66798	0.04380	0.00440	0.05792	0.03765	6.98412	0.00040	0.00017	7.04610
50:1 gas/oil mix	2-stroke	7.5	0.39950	3.71755	0.04439	0.00446	0.05870	0.03815	7.07850	0.00040	0.00018	7.14132
50:1 gas/oil mix	2-stroke	7.6	0.40482	3.76711	0.04498	0.00452	0.05948	0.03866	7.17288	0.00041	0.00018	7.23653

Factors

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
50:1 gas/oil mix	2-stroke	7.7	0.41015	3.81668	0.04557	0.00458	0.06026	0.03917	7.26726	0.00041	0.00018	7.33175
50:1 gas/oil mix	2-stroke	7.8	0.41548	3.86625	0.04616	0.00464	0.06105	0.03968	7.36164	0.00042	0.00018	7.42697
50:1 gas/oil mix	2-stroke	7.9	0.42080	3.91581	0.04676	0.00470	0.06183	0.04019	7.45602	0.00042	0.00018	7.52219
50:1 gas/oil mix	2-stroke	8.0	0.42613	3.96538	0.04735	0.00476	0.06261	0.04070	7.55040	0.00043	0.00019	7.61740
50:1 gas/oil mix	2-stroke	8.1	0.43146	4.01495	0.04794	0.00482	0.06339	0.04121	7.64478	0.00043	0.00019	7.71262
50:1 gas/oil mix	2-stroke	8.2	0.43678	4.06452	0.04853	0.00488	0.06418	0.04171	7.73916	0.00044	0.00019	7.80784
50:1 gas/oil mix	2-stroke	8.3	0.44211	4.11408	0.04912	0.00494	0.06496	0.04222	7.83354	0.00044	0.00019	7.90306
50:1 gas/oil mix	2-stroke	8.4	0.44744	4.16365	0.04972	0.00500	0.06574	0.04273	7.92792	0.00045	0.00020	7.99827
50:1 gas/oil mix	2-stroke	8.5	0.45276	4.21322	0.05031	0.00506	0.06652	0.04324	8.02230	0.00045	0.00020	8.09349
50:1 gas/oil mix	2-stroke	8.6	0.45809	4.26279	0.05090	0.00512	0.06731	0.04375	8.11668	0.00046	0.00020	8.18871
50:1 gas/oil mix	2-stroke	8.7	0.46342	4.31235	0.05149	0.00518	0.06809	0.04426	8.21106	0.00046	0.00020	8.28393
50:1 gas/oil mix	2-stroke	8.8	0.46874	4.36192	0.05208	0.00524	0.06887	0.04477	8.30544	0.00047	0.00021	8.37914
50:1 gas/oil mix	2-stroke	8.9	0.47407	4.41149	0.05267	0.00530	0.06966	0.04528	8.39982	0.00048	0.00021	8.47436
50:1 gas/oil mix	2-stroke	9.0	0.47940	4.46105	0.05327	0.00536	0.07044	0.04578	8.49420	0.00048	0.00021	8.56958
50:1 gas/oil mix	2-stroke	9.1	0.48472	4.51062	0.05386	0.00542	0.07122	0.04629	8.58858	0.00049	0.00021	8.66480
50:1 gas/oil mix	2-stroke	9.2	0.49005	4.56019	0.05445	0.00548	0.07200	0.04680	8.68296	0.00049	0.00022	8.76001
50:1 gas/oil mix	2-stroke	9.3	0.49538	4.60976	0.05504	0.00554	0.07279	0.04731	8.77734	0.00050	0.00022	8.85523
50:1 gas/oil mix	2-stroke	9.4	0.50070	4.65932	0.05563	0.00560	0.07357	0.04782	8.87172	0.00050	0.00022	8.95045
50:1 gas/oil mix	2-stroke	9.5	0.50603	4.70889	0.05623	0.00565	0.07435	0.04833	8.96610	0.00051	0.00022	9.04567
50:1 gas/oil mix	2-stroke	9.6	0.51136	4.75846	0.05682	0.00571	0.07513	0.04884	9.06048	0.00051	0.00022	9.14088
50:1 gas/oil mix	2-stroke	9.7	0.51668	4.80803	0.05741	0.00577	0.07592	0.04935	9.15486	0.00052	0.00023	9.23610
50:1 gas/oil mix	2-stroke	9.8	0.52201	4.85759	0.05800	0.00583	0.07670	0.04985	9.24924	0.00052	0.00023	9.33132
50:1 gas/oil mix	2-stroke	9.9	0.52734	4.90716	0.05859	0.00589	0.07748	0.05036	9.34362	0.00053	0.00023	9.42654
50:1 gas/oil mix	2-stroke	10	0.53266	4.95673	0.05918	0.00595	0.07826	0.05087	7.86500	0.00045	0.00020	7.93480
50:1 gas/oil mix	2-stroke	11	0.58593	5.45240	0.06510	0.00655	0.08609	0.05596	8.65150	0.00049	0.00021	8.72827
50:1 gas/oil mix	2-stroke	12	0.63920	5.94807	0.07102	0.00714	0.09392	0.06105	9.43800	0.00053	0.00023	9.52175
50:1 gas/oil mix	2-stroke	13	0.69246	6.44375	0.07694	0.00774	0.10174	0.06613	10.22450	0.00058	0.00025	10.31523
50:1 gas/oil mix	2-stroke	14	0.74573	6.93942	0.08286	0.00833	0.10957	0.07122	11.01100	0.00062	0.00027	11.10871
50:1 gas/oil mix	2-stroke	15	0.79899	7.43509	0.08878	0.00893	0.11740	0.07631	11.79750	0.00067	0.00029	11.90219
50:1 gas/oil mix	2-stroke	16	0.85226	7.93076	0.09470	0.00952	0.12522	0.08140	12.58400	0.00071	0.00031	12.69567
50:1 gas/oil mix	2-stroke	17	0.90553	8.42644	0.10061	0.01012	0.13305	0.08648	13.37050	0.00076	0.00033	13.48915
50:1 gas/oil mix	2-stroke	18	0.95879	8.92211	0.10653	0.01071	0.14088	0.09157	14.15700	0.00080	0.00035	14.28263
50:1 gas/oil mix	2-stroke	19	1.01206	9.41778	0.11245	0.01131	0.14870	0.09666	14.94350	0.00085	0.00037	15.07611
50:1 gas/oil mix	2-stroke	20	1.06533	9.91346	0.11837	0.01191	0.15653	0.10174	15.73000	0.00089	0.00039	15.86959
50:1 gas/oil mix	2-stroke	21	1.11859	10.40913	0.12429	0.01250	0.16436	0.10683	16.51650	0.00093	0.00041	16.66307
50:1 gas/oil mix	2-stroke	22	1.17186	10.90480	0.13021	0.01310	0.17218	0.11192	17.30300	0.00098	0.00043	17.45655
50:1 gas/oil mix	2-stroke	23	1.22513	11.40047	0.13613	0.01369	0.18001	0.11701	18.08950	0.00102	0.00045	18.25003
50:1 gas/oil mix	2-stroke	24	1.27839	11.89615	0.14204	0.01429	0.18783	0.12209	18.87600	0.00107	0.00047	19.04351
50:1 gas/oil mix	2-stroke	25	1.33166	12.39182	0.14796	0.01488	0.19566	0.12718	19.66250	0.00111	0.00049	19.83699
50:1 gas/oil mix	2-stroke	26	1.38492	12.88749	0.15388	0.01548	0.20349	0.13227	20.44900	0.00116	0.00051	20.63047
50:1 gas/oil mix	2-stroke	27	1.43819	13.38316	0.15980	0.01607	0.21131	0.13735	21.23550	0.00120	0.00053	21.42395
50:1 gas/oil mix	2-stroke	28	1.49146	13.87884	0.16572	0.01667	0.21914	0.14244	22.02200	0.00125	0.00055	22.21743
50:1 gas/oil mix	2-stroke	29	1.54472	14.37451	0.17164	0.01726	0.22697	0.14753	22.80850	0.00129	0.00057	23.01091
50:1 gas/oil mix	2-stroke	30	1.59799	14.87018	0.17755	0.01786	0.23479	0.15262	23.59500	0.00134	0.00059	23.80439
50:1 gas/oil mix	2-stroke	31	1.65126	15.36586	0.18347	0.01845	0.24262	0.15770	24.38150	0.00138	0.00060	24.59786
50:1 gas/oil mix	2-stroke	32	1.70452	15.86153	0.18939	0.01905	0.25045	0.16279	25.16800	0.00142	0.00062	25.39134
50:1 gas/oil mix	2-stroke	33	1.75779	16.35720	0.19531	0.01964	0.25827	0.16788	25.95450	0.00147	0.00064	26.18482
50:1 gas/oil mix	2-stroke	34	1.81106	16.85287	0.20123	0.02024	0.26610	0.17296	26.74100	0.00151	0.00066	26.97830
50:1 gas/oil mix	2-stroke	35	1.86432	17.34855	0.20715	0.02083	0.27393	0.17805	27.52750	0.00156	0.00068	27.77178
50:1 gas/oil mix	2-stroke	36	1.91759	17.84422	0.21307	0.02143	0.28175	0.18314	28.31400	0.00160	0.00070	28.56526
50:1 gas/oil mix	2-stroke	37	1.97085	18.33989	0.21898	0.02202	0.28958	0.18823	29.10050	0.00165	0.00072	29.35874
50:1 gas/oil mix	2-stroke	38	2.02412	18.83557	0.22490	0.02262	0.29741	0.19331	29.88700	0.00169	0.00074	30.15222
50:1 gas/oil mix	2-stroke	39	2.07739	19.33124	0.23082	0.02321	0.30523	0.19840	30.67350	0.00174	0.00076	30.94570
50:1 gas/oil mix	2-stroke	40	2.13065	19.82691	0.23674	0.02381	0.31306	0.20349	31.46000	0.00178	0.00078	31.73918
50:1 gas/oil mix	2-stroke	41	2.18392	20.32258	0.24266	0.02441	0.32088	0.20857	32.24650	0.00182	0.00080	32.53266
50:1 gas/oil mix	2-stroke	42	2.23719	20.81826	0.24858	0.02500	0.32871	0.21366	33.03300	0.00187	0.00082	33.32614
50:1 gas/oil mix	2-stroke	43	2.29045	21.31393	0.25449	0.02560	0.33654	0.21875	33.81950	0.00191	0.00084	34.11962
50:1 gas/oil mix	2-stroke	44	2.34372	21.80960	0.26041	0.02619	0.34436	0.22384	34.60600	0.00196	0.00086	34.91310
50:1 gas/oil mix	2-stroke	45	2.39698	22.30527	0.26633	0.02679	0.35219	0.22892	35.39250	0.00200	0.00088	35.70658
50:1 gas/oil mix	2-stroke	46	2.45025	22.80095	0.27225	0.02738	0.36002	0.23401	36.17900	0.00205	0.00090	36.50006
50:1 gas/oil mix	2-stroke	47	2.50352	23.29662	0.27817	0.02798	0.36784	0.23910	36.96550	0.00209	0.00092	37.29354
50:1 gas/oil mix	2-stroke	48	2.55678	23.79229	0.28409	0.02857	0.37567	0.24419	37.75200	0.00214	0.00094	38.08702
50:1 gas/oil mix	2-stroke	49	2.61005	24.28797	0.29001	0.02917	0.38350	0.24927	38.53850	0.00218	0.00096	38.88050
50:1 gas/oil mix	2-stroke	50	2.66332	24.78364	0.29592	0.02976	0.39132	0.25436	39.32500	0.00223	0.00098	39.67398
50:1 gas/oil mix	2-stroke	51	2.71658	25.27931	0.30184	0.03036	0.39915	0.25945	40.11150	0.00227	0.00099	40.46745
50:1 gas/oil mix	2-stroke	52	2.76985	25.77498	0.30776	0.03095	0.40698	0.26453	40.89800	0.00231	0.00101	41.26093
50:1 gas/oil mix	2-stroke	53	2.82312	26.27066	0.31368	0.03155	0.41480	0.26962	41.68450	0.00236	0.00103	42.05441
50:1 gas/oil mix	2-stroke	54	2.87638	26.76633	0.31960	0.03214	0.42263	0.27471	42.47100	0.00240	0.00105	42.84789
50:1 gas/oil mix	2-stroke	55	2.92965	27.26200	0.32552	0.03274	0.43045	0.27980	43.25750	0.00245	0.00107	43.64137
50:1 gas/oil mix	2-stroke	56	2.98291	27.75768	0.33143	0.03333	0.43828	0.28488	44.04400	0.00249	0.00109	44.43485
50:1 gas/oil mix	2-stroke	57	3.03618	28.25335	0.33735	0.03393	0.44611	0.28997	44.83050	0.00254	0.00111	45.22833
50:1 gas/oil mix	2-stroke	58	3.08945	28.74902	0.34327	0.03452	0.45393	0.29506	45.61700	0.00258	0.00113	46.02181
50:1 gas/oil mix	2-stroke	59	3.14271	29.24469	0.34919	0.03512	0.46176	0.30014	46.40350	0.00263	0.00115	46.81529
50:1 gas/oil mix	2-stroke	60	3.19598	29.74037	0.35511	0.03572	0.46959	0.30523	47.19000	0.00267	0.00117	47.60877
50:1 gas/oil mix	2-stroke	61	3.24925	30.23604	0.36103	0.03631	0.47741	0.31032	47.97650	0.00271	0.00119	48.40225
50:1 gas/oil mix	2-stroke	62	3.30251	30.73171	0.36695	0.03691	0.48524	0.31541	48.76300	0.00276	0.00121	49.19573
50:1 gas/oil mix	2-stroke	63	3.35578	31.22738	0.37286	0.03750	0.49307	0.32049	49.54950	0.00280	0.00123	49.98921
50:1 gas/oil mix	2-stroke	64	3.40905	31.72306	0.37878	0.03810	0.50089	0.32558	50.33600	0.00285	0.00125	50.78269

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
50:1 gas/oil mix	2-stroke	65	3.46231	32.21873	0.38470	0.03869	0.50872	0.33067	51.12250	0.00289	0.00127	51.57617
50:1 gas/oil mix	2-stroke	66	3.51558	32.71440	0.39062	0.03929	0.51655	0.33575	51.90900	0.00294	0.00129	52.36965
50:1 gas/oil mix	2-stroke	67	3.56884	33.21008	0.39654	0.03988	0.52437	0.34084	52.69550	0.00298	0.00131	53.16313
50:1 gas/oil mix	2-stroke	68	3.62211	33.70575	0.40246	0.04048	0.53220	0.34593	53.48200	0.00303	0.00133	53.95661
50:1 gas/oil mix	2-stroke	69	3.67538	34.20142	0.40838	0.04107	0.54003	0.35102	54.26850	0.00307	0.00135	54.75009
50:1 gas/oil mix	2-stroke	70	3.72864	34.69709	0.41429	0.04167	0.54785	0.35610	55.05500	0.00312	0.00137	55.54357
50:1 gas/oil mix	2-stroke	71	3.78191	35.19277	0.42021	0.04226	0.55568	0.36119	55.84150	0.00316	0.00138	56.33704
50:1 gas/oil mix	2-stroke	72	3.83518	35.68844	0.42613	0.04286	0.56350	0.36628	56.62800	0.00320	0.00140	57.13052
50:1 gas/oil mix	2-stroke	73	3.88844	36.18411	0.43205	0.04345	0.57133	0.37137	57.41450	0.00325	0.00142	57.92400
50:1 gas/oil mix	2-stroke	74	3.94171	36.67979	0.43797	0.04405	0.57916	0.37645	58.20100	0.00329	0.00144	58.71748
50:1 gas/oil mix	2-stroke	75	3.99497	37.17546	0.44389	0.04464	0.58698	0.38154	58.98750	0.00334	0.00146	59.51096
50:1 gas/oil mix	2-stroke	76	4.04824	37.67113	0.44980	0.04524	0.59481	0.38663	59.77400	0.00338	0.00148	60.30444
50:1 gas/oil mix	2-stroke	77	4.10151	38.16680	0.45572	0.04583	0.60264	0.39171	60.56050	0.00343	0.00150	61.09792
50:1 gas/oil mix	2-stroke	78	4.15477	38.66248	0.46164	0.04643	0.61046	0.39680	61.34700	0.00347	0.00152	61.89140
50:1 gas/oil mix	2-stroke	79	4.20804	39.15815	0.46756	0.04702	0.61829	0.40189	62.13350	0.00352	0.00154	62.68488
50:1 gas/oil mix	2-stroke	80	4.26131	39.65382	0.47348	0.04762	0.62612	0.40698	62.92000	0.00356	0.00156	63.47836
50:1 gas/oil mix	2-stroke	81	4.31457	40.14949	0.47940	0.04822	0.63394	0.41206	63.70650	0.00360	0.00158	64.27184
50:1 gas/oil mix	2-stroke	82	4.36784	40.64517	0.48532	0.04881	0.64177	0.41715	64.49300	0.00365	0.00160	65.06532
50:1 gas/oil mix	2-stroke	83	4.42111	41.14084	0.49123	0.04941	0.64960	0.42224	65.27950	0.00369	0.00162	65.85880
50:1 gas/oil mix	2-stroke	84	4.47437	41.63651	0.49715	0.05000	0.65742	0.42732	66.06600	0.00374	0.00164	66.65228
50:1 gas/oil mix	2-stroke	85	4.52764	42.13219	0.50307	0.05060	0.66525	0.43241	66.85250	0.00378	0.00166	67.44576
50:1 gas/oil mix	2-stroke	86	4.58090	42.62786	0.50899	0.05119	0.67307	0.43750	67.63900	0.00383	0.00168	68.23924
50:1 gas/oil mix	2-stroke	87	4.63417	43.12353	0.51491	0.05179	0.68090	0.44259	68.42550	0.00387	0.00170	69.03272
50:1 gas/oil mix	2-stroke	88	4.68744	43.61920	0.52083	0.05238	0.68873	0.44767	69.21200	0.00392	0.00172	69.82620
50:1 gas/oil mix	2-stroke	89	4.74070	44.11488	0.52674	0.05298	0.69655	0.45276	69.99850	0.00396	0.00174	70.61968
50:1 gas/oil mix	2-stroke	90	4.79397	44.61055	0.53266	0.05357	0.70438	0.45785	70.78500	0.00401	0.00176	71.41316
50:1 gas/oil mix	2-stroke	91	4.84724	45.10622	0.53858	0.05417	0.71221	0.46293	71.57150	0.00405	0.00177	72.20663
50:1 gas/oil mix	2-stroke	92	4.90050	45.60190	0.54450	0.05476	0.72003	0.46802	72.35800	0.00409	0.00179	73.00011
50:1 gas/oil mix	2-stroke	93	4.95377	46.09757	0.55042	0.05536	0.72786	0.47311	73.14450	0.00414	0.00181	73.79359
50:1 gas/oil mix	2-stroke	94	5.00703	46.59324	0.55634	0.05595	0.73569	0.47820	73.93100	0.00418	0.00183	74.58707
50:1 gas/oil mix	2-stroke	95	5.06030	47.08891	0.56226	0.05655	0.74351	0.48328	74.71750	0.00423	0.00185	75.38055
50:1 gas/oil mix	2-stroke	96	5.11357	47.58459	0.56817	0.05714	0.75134	0.48837	75.50400	0.00427	0.00187	76.17403
50:1 gas/oil mix	2-stroke	97	5.16683	48.08026	0.57409	0.05774	0.75917	0.49346	76.29050	0.00432	0.00189	76.96751
50:1 gas/oil mix	2-stroke	98	5.22010	48.57593	0.58001	0.05833	0.76699	0.49854	77.07700	0.00436	0.00191	77.76099
50:1 gas/oil mix	2-stroke	99	5.27337	49.07160	0.58593	0.05893	0.77482	0.50363	77.86350	0.00441	0.00193	78.55447
50:1 gas/oil mix	2-stroke	100	5.32663	49.56728	0.59185	0.05953	0.78265	0.50872	78.65000	0.00445	0.00195	79.34795
50:1 gas/oil mix	2-stroke	101	5.37990	50.06295	0.59777	0.06012	0.79047	0.51381	79.43650	0.00449	0.00197	80.14143
50:1 gas/oil mix	2-stroke	102	5.43317	50.55862	0.60369	0.06072	0.79830	0.51889	80.22300	0.00454	0.00199	80.93491
50:1 gas/oil mix	2-stroke	103	5.48643	51.05430	0.60960	0.06131	0.80612	0.52398	81.00950	0.00458	0.00201	81.72839
50:1 gas/oil mix	2-stroke	104	5.53970	51.54997	0.61552	0.06191	0.81395	0.52907	81.79600	0.00463	0.00203	82.52187
50:1 gas/oil mix	2-stroke	105	5.59296	52.04564	0.62144	0.06250	0.82178	0.53416	82.58250	0.00467	0.00205	83.31535
50:1 gas/oil mix	2-stroke	106	5.64623	52.54131	0.62736	0.06310	0.82960	0.53924	83.36900	0.00472	0.00207	84.10883
50:1 gas/oil mix	2-stroke	107	5.69950	53.03699	0.63328	0.06369	0.83743	0.54433	84.15550	0.00476	0.00209	84.90231
50:1 gas/oil mix	2-stroke	108	5.75276	53.53266	0.63920	0.06429	0.84526	0.54942	84.94200	0.00481	0.00211	85.69579
50:1 gas/oil mix	2-stroke	109	5.80603	54.02833	0.64511	0.06488	0.85308	0.55450	85.72850	0.00485	0.00213	86.48927
50:1 gas/oil mix	2-stroke	110	5.85930	54.52401	0.65103	0.06548	0.86091	0.55959	86.51500	0.00490	0.00215	87.28275
50:1 gas/oil mix	2-stroke	111	5.91256	55.01968	0.65695	0.06607	0.86874	0.56468	87.30150	0.00494	0.00216	88.07622
50:1 gas/oil mix	2-stroke	112	5.96583	55.51535	0.66287	0.06667	0.87656	0.56977	88.08800	0.00498	0.00218	88.86970
50:1 gas/oil mix	2-stroke	113	6.01910	56.01102	0.66879	0.06726	0.88439	0.57485	88.87450	0.00503	0.00220	89.66318
50:1 gas/oil mix	2-stroke	114	6.07236	56.50670	0.67471	0.06786	0.89222	0.57994	89.66100	0.00507	0.00222	90.45666
50:1 gas/oil mix	2-stroke	115	6.12563	57.00237	0.68063	0.06845	0.90004	0.58503	90.44750	0.00512	0.00224	91.25014
50:1 gas/oil mix	2-stroke	116	6.17889	57.49804	0.68654	0.06905	0.90787	0.59011	91.23400	0.00516	0.00226	92.04362
50:1 gas/oil mix	2-stroke	117	6.23216	57.99371	0.69246	0.06964	0.91569	0.59520	92.02050	0.00521	0.00228	92.83710
50:1 gas/oil mix	2-stroke	118	6.28543	58.48939	0.69838	0.07024	0.92352	0.60029	92.80700	0.00525	0.00230	93.63058
50:1 gas/oil mix	2-stroke	119	6.33869	58.98506	0.70430	0.07083	0.93135	0.60538	93.59350	0.00530	0.00232	94.42406
50:1 gas/oil mix	2-stroke	120	6.39196	59.48073	0.71022	0.07143	0.93917	0.61046	94.38000	0.00534	0.00234	95.21754
50:1 gas/oil mix	2-stroke	121	6.44523	59.97641	0.71614	0.07203	0.94700	0.61555	95.16650	0.00538	0.00236	96.01102
50:1 gas/oil mix	2-stroke	122	6.49849	60.47208	0.72205	0.07262	0.95483	0.62064	95.95300	0.00543	0.00238	96.80450
50:1 gas/oil mix	2-stroke	123	6.55176	60.96775	0.72797	0.07322	0.96265	0.62572	96.73950	0.00547	0.00240	97.59798
50:1 gas/oil mix	2-stroke	124	6.60502	61.46342	0.73389	0.07381	0.97048	0.63081	97.52600	0.00552	0.00242	98.39146
50:1 gas/oil mix	2-stroke	125	6.65829	61.95910	0.73981	0.07441	0.97831	0.63590	98.31250	0.00556	0.00244	99.18494
50:1 gas/oil mix	2-stroke	126	6.71156	62.45477	0.74573	0.07500	0.98613	0.64099	99.09900	0.00561	0.00246	99.97842
50:1 gas/oil mix	2-stroke	127	6.76482	62.95044	0.75165	0.07560	0.99396	0.64607	99.88550	0.00565	0.00248	100.77190
50:1 gas/oil mix	2-stroke	128	6.81809	63.44612	0.75757	0.07619	1.00179	0.65116	100.67200	0.00570	0.00250	101.56538
50:1 gas/oil mix	2-stroke	129	6.87136	63.94179	0.76348	0.07679	1.00961	0.65625	101.45850	0.00574	0.00252	102.35886
50:1 gas/oil mix	2-stroke	130	6.92462	64.43746	0.76940	0.07738	1.01744	0.66134	102.24500	0.00579	0.00254	103.15234
50:1 gas/oil mix	2-stroke	131	6.97789	64.93313	0.77532	0.07798	1.02527	0.66642	103.03150	0.00583	0.00255	103.94581
50:1 gas/oil mix	2-stroke	132	7.03116	65.42881	0.78124	0.07857	1.03309	0.67151	103.81800	0.00587	0.00257	104.73929
50:1 gas/oil mix	2-stroke	133	7.08442	65.92448	0.78716	0.07917	1.04092	0.67660	104.60450	0.00592	0.00259	105.53277
50:1 gas/oil mix	2-stroke	134	7.13769	66.42015	0.79308	0.07976	1.04874	0.68168	105.39100	0.00596	0.00261	106.32625
50:1 gas/oil mix	2-stroke	135	7.19095	66.91582	0.79899	0.08036	1.05657	0.68677	106.17750	0.00601	0.00263	107.11973
50:1 gas/oil mix	2-stroke	136	7.24422	67.41150	0.80491	0.08095	1.06440	0.69186	106.96400	0.00605	0.00265	107.91321
50:1 gas/oil mix	2-stroke	137	7.29749	67.90717	0.81083	0.08155	1.07222	0.69695	107.75050	0.00610	0.00267	108.70669
50:1 gas/oil mix	2-stroke	138	7.35075	68.40284	0.81675	0.08214	1.08005	0.70203	108.53700	0.00614	0.00269	109.50017
50:1 gas/oil mix	2-stroke	139	7.40402	68.89852	0.82267	0.08274	1.08788	0.70712	109.32350	0.00619	0.00271	110.29365
50:1 gas/oil mix	2-stroke	140	7.45729	69.39419	0.82859	0.08334	1.09570	0.71221	110.11000	0.00623	0.00273	111.08713
50:1 gas/oil mix	2-stroke	141	7.51055	69.88986	0.83451	0.08393	1.10353	0.71729	110.89650	0.00627	0.00275	111.88061
50:1 gas/oil mix	2-stroke	142	7.56382	70.38553	0.84042	0.08453	1.11136	0.72238	111.68300	0.00632	0.00277	112.67409

Factors

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
50:1 gas/oil mix	2-stroke	143	7.61708	70.88121	0.84634	0.08512	1.11918	0.72747	112.46950	0.00636	0.00279	113.46757
50:1 gas/oil mix	2-stroke	144	7.67035	71.37688	0.85226	0.08572	1.12701	0.73256	113.25600	0.00641	0.00281	114.26105
50:1 gas/oil mix	2-stroke	145	7.72362	71.87255	0.85818	0.08631	1.13484	0.73764	114.04250	0.00645	0.00283	115.05453
50:1 gas/oil mix	2-stroke	146	7.77688	72.36823	0.86410	0.08691	1.14266	0.74273	114.82900	0.00650	0.00285	115.84801
50:1 gas/oil mix	2-stroke	147	7.83015	72.86390	0.87002	0.08750	1.15049	0.74782	115.61550	0.00654	0.00287	116.64149
50:1 gas/oil mix	2-stroke	148	7.88342	73.35957	0.87594	0.08810	1.15831	0.75290	116.40200	0.00659	0.00289	117.43497
50:1 gas/oil mix	2-stroke	149	7.93668	73.85524	0.88185	0.08869	1.16614	0.75799	117.18850	0.00663	0.00291	118.22845
50:1 gas/oil mix	2-stroke	150	7.98995	74.35092	0.88777	0.08929	1.17397	0.76308	117.97500	0.00668	0.00293	119.02193
50:1 gas/oil mix	2-stroke	151	8.04322	74.84659	0.89369	0.08988	1.18179	0.76817	118.76150	0.00672	0.00294	119.81540
50:1 gas/oil mix	2-stroke	152	8.09648	75.34226	0.89961	0.09048	1.18962	0.77325	119.54800	0.00676	0.00296	120.60888
50:1 gas/oil mix	2-stroke	153	8.14975	75.83793	0.90553	0.09107	1.19745	0.77834	120.33450	0.00681	0.00298	121.40236
50:1 gas/oil mix	2-stroke	154	8.20301	76.33361	0.91145	0.09167	1.20527	0.78343	121.12100	0.00685	0.00300	122.19584
50:1 gas/oil mix	2-stroke	155	8.25628	76.82928	0.91736	0.09226	1.21310	0.78851	121.90750	0.00690	0.00302	122.98932
50:1 gas/oil mix	2-stroke	156	8.30955	77.32495	0.92328	0.09286	1.22093	0.79360	122.69400	0.00694	0.00304	123.78280
50:1 gas/oil mix	2-stroke	157	8.36281	77.82063	0.92920	0.09345	1.22875	0.79869	123.48050	0.00699	0.00306	124.57628
50:1 gas/oil mix	2-stroke	158	8.41608	78.31630	0.93512	0.09405	1.23658	0.80378	124.26700	0.00703	0.00308	125.36976
50:1 gas/oil mix	2-stroke	159	8.46935	78.81197	0.94104	0.09464	1.24441	0.80886	125.05350	0.00708	0.00310	126.16324
50:1 gas/oil mix	2-stroke	160	8.52261	79.30764	0.94696	0.09524	1.25223	0.81395	125.84000	0.00712	0.00312	126.95672
50:1 gas/oil mix	2-stroke	161	8.57588	79.80332	0.95288	0.09584	1.26006	0.81904	126.62650	0.00716	0.00314	127.75020
50:1 gas/oil mix	2-stroke	162	8.62915	80.29899	0.95879	0.09643	1.26789	0.82413	127.41300	0.00721	0.00316	128.54368
50:1 gas/oil mix	2-stroke	163	8.68241	80.79466	0.96471	0.09703	1.27571	0.82921	128.19950	0.00725	0.00318	129.33716
50:1 gas/oil mix	2-stroke	164	8.73568	81.29034	0.97063	0.09762	1.28354	0.83430	128.98600	0.00730	0.00320	130.13064
50:1 gas/oil mix	2-stroke	165	8.78894	81.78601	0.97655	0.09822	1.29136	0.83939	129.77250	0.00734	0.00322	130.92412
50:1 gas/oil mix	2-stroke	166	8.84221	82.28168	0.98247	0.09881	1.29919	0.84447	130.55900	0.00739	0.00324	131.71760
50:1 gas/oil mix	2-stroke	167	8.89548	82.77735	0.98839	0.09941	1.30702	0.84956	131.34550	0.00743	0.00326	132.51108
50:1 gas/oil mix	2-stroke	168	8.94874	83.27303	0.99430	0.10000	1.31484	0.85465	132.13200	0.00748	0.00328	133.30456
50:1 gas/oil mix	2-stroke	169	9.00201	83.76870	1.00022	0.10060	1.32267	0.85974	132.91850	0.00752	0.00330	134.09804
50:1 gas/oil mix	2-stroke	170	9.05528	84.26437	1.00614	0.10119	1.33050	0.86482	133.70500	0.00757	0.00332	134.89152
50:1 gas/oil mix	2-stroke	171	9.10854	84.76004	1.01206	0.10179	1.33832	0.86991	134.49150	0.00761	0.00333	135.68499
50:1 gas/oil mix	2-stroke	172	9.16181	85.25572	1.01798	0.10238	1.34615	0.87500	135.27800	0.00765	0.00335	136.47847
50:1 gas/oil mix	2-stroke	173	9.21507	85.75139	1.02390	0.10298	1.35398	0.88008	136.06450	0.00770	0.00337	137.27195
50:1 gas/oil mix	2-stroke	174	9.26834	86.24706	1.02982	0.10357	1.36180	0.88517	136.85100	0.00774	0.00339	138.06543
50:1 gas/oil mix	2-stroke	175	9.32161	86.74274	1.03573	0.10417	1.36963	0.89026	137.63750	0.00779	0.00341	138.85891
50:1 gas/oil mix	2-stroke	176	9.37487	87.23841	1.04165	0.10476	1.37746	0.89535	138.42400	0.00783	0.00343	139.65239
50:1 gas/oil mix	2-stroke	177	9.42814	87.73408	1.04757	0.10536	1.38528	0.90043	139.21050	0.00788	0.00345	140.44587
50:1 gas/oil mix	2-stroke	178	9.48141	88.22975	1.05349	0.10595	1.39311	0.90552	139.99700	0.00792	0.00347	141.23935
50:1 gas/oil mix	2-stroke	179	9.53467	88.72543	1.05941	0.10655	1.40093	0.91061	140.78350	0.00797	0.00349	142.03283
50:1 gas/oil mix	2-stroke	180	9.58794	89.22110	1.06533	0.10715	1.40876	0.91569	141.57000	0.00801	0.00351	142.82631
50:1 gas/oil mix	2-stroke	181	9.64121	89.71677	1.07125	0.10774	1.41659	0.92078	142.35650	0.00805	0.00353	143.61979
50:1 gas/oil mix	2-stroke	182	9.69447	90.21245	1.07716	0.10834	1.42441	0.92587	143.14300	0.00810	0.00355	144.41327
50:1 gas/oil mix	2-stroke	183	9.74774	90.70812	1.08308	0.10893	1.43224	0.93096	143.92950	0.00814	0.00357	145.20675
50:1 gas/oil mix	2-stroke	184	9.80100	91.20379	1.08900	0.10953	1.44007	0.93604	144.71600	0.00819	0.00359	146.00023
50:1 gas/oil mix	2-stroke	185	9.85427	91.69946	1.09492	0.11012	1.44789	0.94113	145.50250	0.00823	0.00361	146.79371
50:1 gas/oil mix	2-stroke	186	9.90754	92.19514	1.10084	0.11072	1.45572	0.94622	146.28900	0.00828	0.00363	147.58719
50:1 gas/oil mix	2-stroke	187	9.96080	92.69081	1.10676	0.11131	1.46355	0.95131	147.07550	0.00832	0.00365	148.38067
50:1 gas/oil mix	2-stroke	188	10.01407	93.18648	1.11267	0.11191	1.47137	0.95639	147.86200	0.00837	0.00367	149.17415
50:1 gas/oil mix	2-stroke	189	10.06734	93.68215	1.11859	0.11250	1.47920	0.96148	148.64850	0.00841	0.00369	149.96763
50:1 gas/oil mix	2-stroke	190	10.12060	94.17783	1.12451	0.11310	1.48703	0.96657	149.43500	0.00846	0.00371	150.76111
50:1 gas/oil mix	2-stroke	191	10.17387	94.67350	1.13043	0.11369	1.49485	0.97165	150.22150	0.00850	0.00372	151.55458
50:1 gas/oil mix	2-stroke	192	10.22714	95.16917	1.13635	0.11429	1.50268	0.97674	151.00800	0.00854	0.00374	152.34806
50:1 gas/oil mix	2-stroke	193	10.28040	95.66485	1.14227	0.11488	1.51051	0.98183	151.79450	0.00859	0.00376	153.14154
50:1 gas/oil mix	2-stroke	194	10.33367	96.16052	1.14819	0.11548	1.51833	0.98692	152.58100	0.00863	0.00378	153.93502
50:1 gas/oil mix	2-stroke	195	10.38693	96.65619	1.15410	0.11607	1.52616	0.99200	153.36750	0.00868	0.00380	154.72850
50:1 gas/oil mix	2-stroke	196	10.44020	97.15186	1.16002	0.11667	1.53398	0.99709	154.15400	0.00872	0.00382	155.52198
50:1 gas/oil mix	2-stroke	197	10.49347	97.64754	1.16594	0.11726	1.54181	1.00218	154.94050	0.00877	0.00384	156.31546
50:1 gas/oil mix	2-stroke	198	10.54673	98.14321	1.17186	0.11786	1.54964	1.00726	155.72700	0.00881	0.00386	157.10894
50:1 gas/oil mix	2-stroke	199	10.60000	98.63888	1.17778	0.11845	1.55746	1.01235	156.51350	0.00886	0.00388	157.90242
50:1 gas/oil mix	2-stroke	200	10.65327	99.13456	1.18370	0.11905	1.56529	1.01744	157.30000	0.00890	0.00390	158.69590
Methane	**Methane**	**10**	**0.07938**	**0.03342**	**0.05082**	**0.00004**	**0.00060**	**0.00039**	**6.99600**	**0.00014**	**0.00001**	**7.00262**
CNG	Methane	11	0.08732	0.03676	0.05590	0.00004	0.00066	0.00043	7.69560	0.00015	0.00001	7.70288
CNG	Methane	12	0.09526	0.04010	0.06098	0.00004	0.00072	0.00047	8.39520	0.00017	0.00001	8.40314
CNG	Methane	13	0.10319	0.04345	0.06607	0.00005	0.00078	0.00051	9.09480	0.00018	0.00002	9.10340
CNG	Methane	14	0.11113	0.04679	0.07115	0.00005	0.00084	0.00055	9.79440	0.00019	0.00002	9.80367
CNG	Methane	15	0.11907	0.05013	0.07623	0.00005	0.00090	0.00059	10.49400	0.00021	0.00002	10.50393
CNG	Methane	16	0.12701	0.05347	0.08131	0.00006	0.00096	0.00062	11.19360	0.00022	0.00002	11.20419
CNG	Methane	17	0.13495	0.05681	0.08639	0.00006	0.00102	0.00066	11.89320	0.00023	0.00002	11.90445
CNG	Methane	18	0.14288	0.06016	0.09148	0.00006	0.00108	0.00070	12.59280	0.00025	0.00002	12.60471
CNG	Methane	19	0.15082	0.06350	0.09656	0.00007	0.00114	0.00074	13.29240	0.00026	0.00002	13.30497
CNG	Methane	20	0.15876	0.06684	0.10164	0.00007	0.00120	0.00078	13.99200	0.00028	0.00002	14.00524
CNG	Methane	21	0.16670	0.07018	0.10672	0.00008	0.00126	0.00082	14.69160	0.00029	0.00003	14.70550
CNG	Methane	22	0.17464	0.07352	0.11180	0.00008	0.00132	0.00086	15.39120	0.00030	0.00003	15.40576
CNG	Methane	23	0.18257	0.07687	0.11689	0.00008	0.00138	0.00090	16.09080	0.00032	0.00003	16.10602
CNG	Methane	24	0.19051	0.08021	0.12197	0.00009	0.00144	0.00094	16.79040	0.00033	0.00003	16.80628
CNG	Methane	25	0.19845	0.08355	0.12705	0.00009	0.00150	0.00098	17.49000	0.00035	0.00003	17.50655
CNG	Methane	26	0.20639	0.08689	0.13213	0.00009	0.00156	0.00101	18.18960	0.00036	0.00003	18.20681
CNG	Methane	27	0.21433	0.09023	0.13721	0.00010	0.00162	0.00105	18.88920	0.00037	0.00003	18.90707
CNG	Methane	28	0.22226	0.09358	0.14230	0.00010	0.00168	0.00109	19.58880	0.00039	0.00003	19.60733
CNG	Methane	29	0.23020	0.09692	0.14738	0.00010	0.00174	0.00113	20.28840	0.00040	0.00003	20.30759

Factors

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
CNG	Methane	30	0.23814	0.10026	0.15246	0.00011	0.00180	0.00117	20.98800	0.00041	0.00004	21.00785
CNG	Methane	31	0.24608	0.10360	0.15754	0.00011	0.00186	0.00121	21.68760	0.00043	0.00004	21.70812
CNG	Methane	32	0.25402	0.10694	0.16262	0.00012	0.00192	0.00125	22.38720	0.00044	0.00004	22.40838
CNG	Methane	33	0.26195	0.11029	0.16771	0.00012	0.00198	0.00129	23.08680	0.00046	0.00004	23.10864
CNG	Methane	34	0.26989	0.11363	0.17279	0.00012	0.00204	0.00133	23.78640	0.00047	0.00004	23.80890
CNG	Methane	35	0.27783	0.11697	0.17787	0.00013	0.00210	0.00137	24.48600	0.00048	0.00004	24.50916
CNG	Methane	36	0.28577	0.12031	0.18295	0.00013	0.00216	0.00140	25.18560	0.00050	0.00004	25.20942
CNG	Methane	37	0.29371	0.12365	0.18803	0.00013	0.00222	0.00144	25.88520	0.00051	0.00004	25.90969
CNG	Methane	38	0.30164	0.12700	0.19312	0.00014	0.00228	0.00148	26.58480	0.00052	0.00005	26.60995
CNG	Methane	39	0.30958	0.13034	0.19820	0.00014	0.00234	0.00152	27.28440	0.00054	0.00005	27.31021
CNG	Methane	40	0.31752	0.13368	0.20328	0.00014	0.00240	0.00156	27.98400	0.00055	0.00005	28.01047
CNG	Methane	41	0.32546	0.13702	0.20836	0.00015	0.00246	0.00160	28.68360	0.00057	0.00005	28.71073
CNG	Methane	42	0.33340	0.14036	0.21344	0.00015	0.00252	0.00164	29.38320	0.00058	0.00005	29.41100
CNG	Methane	43	0.34133	0.14371	0.21853	0.00015	0.00258	0.00168	30.08280	0.00059	0.00005	30.11126
CNG	Methane	44	0.34927	0.14705	0.22361	0.00016	0.00264	0.00172	30.78240	0.00061	0.00005	30.81152
CNG	Methane	45	0.35721	0.15039	0.22869	0.00016	0.00270	0.00176	31.48200	0.00062	0.00005	31.51178
CNG	Methane	46	0.36515	0.15373	0.23377	0.00017	0.00276	0.00179	32.18160	0.00063	0.00006	32.21204
CNG	Methane	47	0.37309	0.15707	0.23885	0.00017	0.00282	0.00183	32.88120	0.00065	0.00006	32.91230
CNG	Methane	48	0.38102	0.16042	0.24394	0.00017	0.00288	0.00187	33.58080	0.00066	0.00006	33.61257
CNG	Methane	49	0.38896	0.16376	0.24902	0.00018	0.00294	0.00191	34.28040	0.00068	0.00006	34.31283
CNG	Methane	50	0.39690	0.16710	0.25410	0.00018	0.00300	0.00195	34.98000	0.00069	0.00006	35.01309
CNG	Methane	51	0.40484	0.17044	0.25918	0.00018	0.00306	0.00199	35.67960	0.00070	0.00006	35.71335
CNG	Methane	52	0.41278	0.17378	0.26426	0.00019	0.00312	0.00203	36.37920	0.00072	0.00006	36.41361
CNG	Methane	53	0.42071	0.17713	0.26935	0.00019	0.00318	0.00207	37.07880	0.00073	0.00006	37.11388
CNG	Methane	54	0.42865	0.18047	0.27443	0.00019	0.00324	0.00211	37.77840	0.00075	0.00006	37.81414
CNG	Methane	55	0.43659	0.18381	0.27951	0.00020	0.00330	0.00215	38.47800	0.00076	0.00007	38.51440
CNG	Methane	56	0.44453	0.18715	0.28459	0.00020	0.00336	0.00218	39.17760	0.00077	0.00007	39.21466
CNG	Methane	57	0.45247	0.19049	0.28967	0.00021	0.00342	0.00222	39.87720	0.00079	0.00007	39.91492
CNG	Methane	58	0.46040	0.19384	0.29476	0.00021	0.00348	0.00226	40.57680	0.00080	0.00007	40.61518
CNG	Methane	59	0.46834	0.19718	0.29984	0.00021	0.00354	0.00230	41.27640	0.00081	0.00007	41.31545
CNG	Methane	60	0.47628	0.20052	0.30492	0.00022	0.00360	0.00234	41.97600	0.00083	0.00007	42.01571
CNG	Methane	61	0.48422	0.20386	0.31000	0.00022	0.00366	0.00238	42.67560	0.00084	0.00007	42.71597
CNG	Methane	62	0.49216	0.20720	0.31508	0.00022	0.00372	0.00242	43.37520	0.00086	0.00007	43.41623
CNG	Methane	63	0.50009	0.21055	0.32017	0.00023	0.00378	0.00246	44.07480	0.00087	0.00008	44.11649
CNG	Methane	64	0.50803	0.21389	0.32525	0.00023	0.00384	0.00250	44.77440	0.00088	0.00008	44.81676
CNG	Methane	65	0.51597	0.21723	0.33033	0.00023	0.00390	0.00254	45.47400	0.00090	0.00008	45.51702
CNG	Methane	66	0.52391	0.22057	0.33541	0.00024	0.00396	0.00257	46.17360	0.00091	0.00008	46.21728
CNG	Methane	67	0.53185	0.22391	0.34049	0.00024	0.00402	0.00261	46.87320	0.00092	0.00008	46.91754
CNG	Methane	68	0.53978	0.22726	0.34558	0.00024	0.00408	0.00265	47.57280	0.00094	0.00008	47.61780
CNG	Methane	69	0.54772	0.23060	0.35066	0.00025	0.00414	0.00269	48.27240	0.00095	0.00008	48.31806
CNG	Methane	70	0.55566	0.23394	0.35574	0.00025	0.00420	0.00273	48.97200	0.00097	0.00008	49.01833
CNG	Methane	71	0.56360	0.23728	0.36082	0.00026	0.00426	0.00277	49.67160	0.00098	0.00009	49.71859
CNG	Methane	72	0.57154	0.24062	0.36590	0.00026	0.00432	0.00281	50.37120	0.00099	0.00009	50.41885
CNG	Methane	73	0.57947	0.24397	0.37099	0.00026	0.00438	0.00285	51.07080	0.00101	0.00009	51.11911
CNG	Methane	74	0.58741	0.24731	0.37607	0.00027	0.00444	0.00289	51.77040	0.00102	0.00009	51.81937
CNG	Methane	75	0.59535	0.25065	0.38115	0.00027	0.00450	0.00293	52.47000	0.00104	0.00009	52.51964
CNG	Methane	76	0.60329	0.25399	0.38623	0.00027	0.00456	0.00296	53.16960	0.00105	0.00009	53.21990
CNG	Methane	77	0.61123	0.25733	0.39131	0.00028	0.00462	0.00300	53.86920	0.00106	0.00009	53.92016
CNG	Methane	78	0.61916	0.26068	0.39640	0.00028	0.00468	0.00304	54.56880	0.00108	0.00009	54.62042
CNG	Methane	79	0.62710	0.26402	0.40148	0.00028	0.00474	0.00308	55.26840	0.00109	0.00009	55.32068
CNG	Methane	80	0.63504	0.26736	0.40656	0.00029	0.00480	0.00312	55.96800	0.00110	0.00010	56.02094
CNG	Methane	81	0.64298	0.27070	0.41164	0.00029	0.00486	0.00316	56.66760	0.00112	0.00010	56.72121
CNG	Methane	82	0.65092	0.27404	0.41672	0.00030	0.00492	0.00320	57.36720	0.00113	0.00010	57.42147
CNG	Methane	83	0.65885	0.27739	0.42181	0.00030	0.00498	0.00324	58.06680	0.00115	0.00010	58.12173
CNG	Methane	84	0.66679	0.28073	0.42689	0.00030	0.00504	0.00328	58.76640	0.00116	0.00010	58.82199
CNG	Methane	85	0.67473	0.28407	0.43197	0.00031	0.00510	0.00332	59.46600	0.00117	0.00010	59.52225
CNG	Methane	86	0.68267	0.28741	0.43705	0.00031	0.00516	0.00335	60.16560	0.00119	0.00010	60.22251
CNG	Methane	87	0.69061	0.29075	0.44213	0.00031	0.00522	0.00339	60.86520	0.00120	0.00010	60.92278
CNG	Methane	88	0.69854	0.29410	0.44722	0.00032	0.00528	0.00343	61.56480	0.00121	0.00011	61.62304
CNG	Methane	89	0.70648	0.29744	0.45230	0.00032	0.00534	0.00347	62.26440	0.00123	0.00011	62.32330
CNG	Methane	90	0.71442	0.30078	0.45738	0.00032	0.00540	0.00351	62.96400	0.00124	0.00011	63.02356
CNG	Methane	91	0.72236	0.30412	0.46246	0.00033	0.00546	0.00355	63.66360	0.00126	0.00011	63.72382
CNG	Methane	92	0.73030	0.30746	0.46754	0.00033	0.00552	0.00359	64.36320	0.00127	0.00011	64.42409
CNG	Methane	93	0.73823	0.31081	0.47263	0.00033	0.00558	0.00363	65.06280	0.00128	0.00011	65.12435
CNG	Methane	94	0.74617	0.31415	0.47771	0.00034	0.00564	0.00367	65.76240	0.00130	0.00011	65.82461
CNG	Methane	95	0.75411	0.31749	0.48279	0.00034	0.00570	0.00371	66.46200	0.00131	0.00011	66.52487
CNG	Methane	96	0.76205	0.32083	0.48787	0.00035	0.00576	0.00374	67.16160	0.00132	0.00012	67.22513
CNG	Methane	97	0.76999	0.32417	0.49295	0.00035	0.00582	0.00378	67.86120	0.00134	0.00012	67.92539
CNG	Methane	98	0.77792	0.32752	0.49804	0.00035	0.00588	0.00382	68.56080	0.00135	0.00012	68.62566
CNG	Methane	99	0.78586	0.33086	0.50312	0.00036	0.00594	0.00386	69.26040	0.00137	0.00012	69.32592
CNG	Methane	100	0.79380	0.33420	0.50820	0.00036	0.00600	0.00390	69.96000	0.00138	0.00012	70.02618
CNG	Methane	101	0.80174	0.33754	0.51328	0.00036	0.00606	0.00394	70.65960	0.00139	0.00012	70.72644
CNG	Methane	102	0.80968	0.34088	0.51836	0.00037	0.00612	0.00398	71.35920	0.00141	0.00012	71.42670
CNG	Methane	103	0.81761	0.34423	0.52345	0.00037	0.00618	0.00402	72.05880	0.00142	0.00012	72.12697
CNG	Methane	104	0.82555	0.34757	0.52853	0.00037	0.00624	0.00406	72.75840	0.00144	0.00012	72.82723
CNG	Methane	105	0.83349	0.35091	0.53361	0.00038	0.00630	0.00410	73.45800	0.00145	0.00013	73.52749
CNG	Methane	106	0.84143	0.35425	0.53869	0.00038	0.00636	0.00413	74.15760	0.00146	0.00013	74.22775
CNG	Methane	107	0.84937	0.35759	0.54377	0.00039	0.00642	0.00417	74.85720	0.00148	0.00013	74.92801

Factors

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
CNG	Methane	108	0.85730	0.36094	0.54886	0.00039	0.00648	0.00421	75.55680	0.00149	0.00013	75.62827
CNG	Methane	109	0.86524	0.36428	0.55394	0.00039	0.00654	0.00425	76.25640	0.00150	0.00013	76.32854
CNG	Methane	110	0.87318	0.36762	0.55902	0.00040	0.00660	0.00429	76.95600	0.00152	0.00013	77.02880
CNG	Methane	111	0.88112	0.37096	0.56410	0.00040	0.00666	0.00433	77.65560	0.00153	0.00013	77.72906
CNG	Methane	112	0.88906	0.37430	0.56918	0.00040	0.00672	0.00437	78.35520	0.00155	0.00013	78.42932
CNG	Methane	113	0.89699	0.37765	0.57427	0.00041	0.00678	0.00441	79.05480	0.00156	0.00014	79.12958
CNG	Methane	114	0.90493	0.38099	0.57935	0.00041	0.00684	0.00445	79.75440	0.00157	0.00014	79.82985
CNG	Methane	115	0.91287	0.38433	0.58443	0.00041	0.00690	0.00449	80.45400	0.00159	0.00014	80.53011
CNG	Methane	116	0.92081	0.38767	0.58951	0.00042	0.00696	0.00452	81.15360	0.00160	0.00014	81.23037
CNG	Methane	117	0.92875	0.39101	0.59459	0.00042	0.00702	0.00456	81.85320	0.00161	0.00014	81.93063
CNG	Methane	118	0.93668	0.39436	0.59968	0.00042	0.00708	0.00460	82.55280	0.00163	0.00014	82.63089
CNG	Methane	119	0.94462	0.39770	0.60476	0.00043	0.00714	0.00464	83.25240	0.00164	0.00014	83.33115
CNG	Methane	120	0.95256	0.40104	0.60984	0.00043	0.00720	0.00468	83.95200	0.00166	0.00014	84.03142
CNG	Methane	121	0.96050	0.40438	0.61492	0.00044	0.00726	0.00472	84.65160	0.00167	0.00015	84.73168
CNG	Methane	122	0.96844	0.40772	0.62000	0.00044	0.00732	0.00476	85.35120	0.00168	0.00015	85.43194
CNG	Methane	123	0.97637	0.41107	0.62509	0.00044	0.00738	0.00480	86.05080	0.00170	0.00015	86.13220
CNG	Methane	124	0.98431	0.41441	0.63017	0.00045	0.00744	0.00484	86.75040	0.00171	0.00015	86.83246
CNG	Methane	125	0.99225	0.41775	0.63525	0.00045	0.00750	0.00488	87.45000	0.00173	0.00015	87.53273
CNG	Methane	126	1.00019	0.42109	0.64033	0.00045	0.00756	0.00491	88.14960	0.00174	0.00015	88.23299
CNG	Methane	127	1.00813	0.42443	0.64541	0.00046	0.00762	0.00495	88.84920	0.00175	0.00015	88.93325
CNG	Methane	128	1.01606	0.42778	0.65050	0.00046	0.00768	0.00499	89.54880	0.00177	0.00015	89.63351
CNG	Methane	129	1.02400	0.43112	0.65558	0.00046	0.00774	0.00503	90.24840	0.00178	0.00015	90.33377
CNG	Methane	130	1.03194	0.43446	0.66066	0.00047	0.00780	0.00507	90.94800	0.00179	0.00016	91.03403
CNG	Methane	131	1.03988	0.43780	0.66574	0.00047	0.00786	0.00511	91.64760	0.00181	0.00016	91.73430
CNG	Methane	132	1.04782	0.44114	0.67082	0.00048	0.00792	0.00515	92.34720	0.00182	0.00016	92.43456
CNG	Methane	133	1.05575	0.44449	0.67591	0.00048	0.00798	0.00519	93.04680	0.00184	0.00016	93.13482
CNG	Methane	134	1.06369	0.44783	0.68099	0.00048	0.00804	0.00523	93.74640	0.00185	0.00016	93.83508
CNG	Methane	135	1.07163	0.45117	0.68607	0.00049	0.00810	0.00527	94.44600	0.00186	0.00016	94.53534
CNG	Methane	136	1.07957	0.45451	0.69115	0.00049	0.00816	0.00530	95.14560	0.00188	0.00016	95.23560
CNG	Methane	137	1.08751	0.45785	0.69623	0.00049	0.00822	0.00534	95.84520	0.00189	0.00016	95.93587
CNG	Methane	138	1.09544	0.46120	0.70132	0.00050	0.00828	0.00538	96.54480	0.00190	0.00017	96.63613
CNG	Methane	139	1.10338	0.46454	0.70640	0.00050	0.00834	0.00542	97.24440	0.00192	0.00017	97.33639
CNG	Methane	140	1.11132	0.46788	0.71148	0.00050	0.00840	0.00546	97.94400	0.00193	0.00017	98.03665
CNG	Methane	141	1.11926	0.47122	0.71656	0.00051	0.00846	0.00550	98.64360	0.00195	0.00017	98.73691
CNG	Methane	142	1.12720	0.47456	0.72164	0.00051	0.00852	0.00554	99.34320	0.00196	0.00017	99.43718
CNG	Methane	143	1.13513	0.47791	0.72673	0.00051	0.00858	0.00558	100.04280	0.00197	0.00017	100.13744
CNG	Methane	144	1.14307	0.48125	0.73181	0.00052	0.00864	0.00562	100.74240	0.00199	0.00017	100.83770
CNG	Methane	145	1.15101	0.48459	0.73689	0.00052	0.00870	0.00566	101.44200	0.00200	0.00017	101.53796
CNG	Methane	146	1.15895	0.48793	0.74197	0.00053	0.00876	0.00569	102.14160	0.00201	0.00018	102.23822
CNG	Methane	147	1.16689	0.49127	0.74705	0.00053	0.00882	0.00573	102.84120	0.00203	0.00018	102.93848
CNG	Methane	148	1.17482	0.49462	0.75214	0.00053	0.00888	0.00577	103.54080	0.00204	0.00018	103.63875
CNG	Methane	149	1.18276	0.49796	0.75722	0.00054	0.00894	0.00581	104.24040	0.00206	0.00018	104.33901
CNG	Methane	150	1.19070	0.50130	0.76230	0.00054	0.00900	0.00585	104.94000	0.00207	0.00018	105.03927
CNG	Methane	151	1.19864	0.50464	0.76738	0.00054	0.00906	0.00589	105.63960	0.00208	0.00018	105.73953
CNG	Methane	152	1.20658	0.50798	0.77246	0.00055	0.00912	0.00593	106.33920	0.00210	0.00018	106.43979
CNG	Methane	153	1.21451	0.51133	0.77755	0.00055	0.00918	0.00597	107.03880	0.00211	0.00018	107.14006
CNG	Methane	154	1.22245	0.51467	0.78263	0.00055	0.00924	0.00601	107.73840	0.00213	0.00018	107.84032
CNG	Methane	155	1.23039	0.51801	0.78771	0.00056	0.00930	0.00605	108.43800	0.00214	0.00019	108.54058
CNG	Methane	156	1.23833	0.52135	0.79279	0.00056	0.00936	0.00608	109.13760	0.00215	0.00019	109.24084
CNG	Methane	157	1.24627	0.52469	0.79787	0.00057	0.00942	0.00612	109.83720	0.00217	0.00019	109.94110
CNG	Methane	158	1.25420	0.52804	0.80296	0.00057	0.00948	0.00616	110.53680	0.00218	0.00019	110.64136
CNG	Methane	159	1.26214	0.53138	0.80804	0.00057	0.00954	0.00620	111.23640	0.00219	0.00019	111.34163
CNG	Methane	160	1.27008	0.53472	0.81312	0.00058	0.00960	0.00624	111.93600	0.00221	0.00019	112.04189
CNG	Methane	161	1.27802	0.53806	0.81820	0.00058	0.00966	0.00628	112.63560	0.00222	0.00019	112.74215
CNG	Methane	162	1.28596	0.54140	0.82328	0.00058	0.00972	0.00632	113.33520	0.00224	0.00019	113.44241
CNG	Methane	163	1.29389	0.54475	0.82837	0.00059	0.00978	0.00636	114.03480	0.00225	0.00020	114.14267
CNG	Methane	164	1.30183	0.54809	0.83345	0.00059	0.00984	0.00640	114.73440	0.00226	0.00020	114.84294
CNG	Methane	165	1.30977	0.55143	0.83853	0.00059	0.00990	0.00644	115.43400	0.00228	0.00020	115.54320
CNG	Methane	166	1.31771	0.55477	0.84361	0.00060	0.00996	0.00647	116.13360	0.00229	0.00020	116.24346
CNG	Methane	167	1.32565	0.55811	0.84869	0.00060	0.01002	0.00651	116.83320	0.00230	0.00020	116.94372
CNG	Methane	168	1.33358	0.56146	0.85378	0.00060	0.01008	0.00655	117.53280	0.00232	0.00020	117.64398
CNG	Methane	169	1.34152	0.56480	0.85886	0.00061	0.01014	0.00659	118.23240	0.00233	0.00020	118.34424
CNG	Methane	170	1.34946	0.56814	0.86394	0.00061	0.01020	0.00663	118.93200	0.00235	0.00020	119.04451
CNG	Methane	171	1.35740	0.57148	0.86902	0.00062	0.01026	0.00667	119.63160	0.00236	0.00021	119.74477
CNG	Methane	172	1.36534	0.57482	0.87410	0.00062	0.01032	0.00671	120.33120	0.00237	0.00021	120.44503
CNG	Methane	173	1.37327	0.57817	0.87919	0.00062	0.01038	0.00675	121.03080	0.00239	0.00021	121.14529
CNG	Methane	174	1.38121	0.58151	0.88427	0.00063	0.01044	0.00679	121.73040	0.00240	0.00021	121.84555
CNG	Methane	175	1.38915	0.58485	0.88935	0.00063	0.01050	0.00683	122.43000	0.00242	0.00021	122.54582
CNG	Methane	176	1.39709	0.58819	0.89443	0.00063	0.01056	0.00686	123.12960	0.00243	0.00021	123.24608
CNG	Methane	177	1.40503	0.59153	0.89951	0.00064	0.01062	0.00690	123.82920	0.00244	0.00021	123.94634
CNG	Methane	178	1.41296	0.59488	0.90460	0.00064	0.01068	0.00694	124.52880	0.00246	0.00021	124.64660
CNG	Methane	179	1.42090	0.59822	0.90968	0.00064	0.01074	0.00698	125.22840	0.00247	0.00021	125.34686
CNG	Methane	180	1.42884	0.60156	0.91476	0.00065	0.01080	0.00702	125.92800	0.00248	0.00022	126.04712
CNG	Methane	181	1.43678	0.60490	0.91984	0.00065	0.01086	0.00706	126.62760	0.00250	0.00022	126.74739
CNG	Methane	182	1.44472	0.60824	0.92492	0.00066	0.01092	0.00710	127.32720	0.00251	0.00022	127.44765
CNG	Methane	183	1.45265	0.61159	0.93001	0.00066	0.01098	0.00714	128.02680	0.00253	0.00022	128.14791
CNG	Methane	184	1.46059	0.61493	0.93509	0.00066	0.01104	0.00718	128.72640	0.00254	0.00022	128.84817
CNG	Methane	185	1.46853	0.61827	0.94017	0.00067	0.01110	0.00722	129.42600	0.00255	0.00022	129.54843

Factors

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
CNG	Methane	186	1.47647	0.62161	0.94525	0.00067	0.01116	0.00725	130.12560	0.00257	0.00022	130.24869
CNG	Methane	187	1.48441	0.62495	0.95033	0.00067	0.01122	0.00729	130.82520	0.00258	0.00022	130.94896
CNG	Methane	188	1.49234	0.62830	0.95542	0.00068	0.01128	0.00733	131.52480	0.00259	0.00023	131.64922
CNG	Methane	189	1.50028	0.63164	0.96050	0.00068	0.01134	0.00737	132.22440	0.00261	0.00023	132.34948
CNG	Methane	190	1.50822	0.63498	0.96558	0.00068	0.01140	0.00741	132.92400	0.00262	0.00023	133.04974
CNG	Methane	191	1.51616	0.63832	0.97066	0.00069	0.01146	0.00745	133.62360	0.00264	0.00023	133.75000
CNG	Methane	192	1.52410	0.64166	0.97574	0.00069	0.01152	0.00749	134.32320	0.00265	0.00023	134.45027
CNG	Methane	193	1.53203	0.64501	0.98083	0.00069	0.01158	0.00753	135.02280	0.00266	0.00023	135.15053
CNG	Methane	194	1.53997	0.64835	0.98591	0.00070	0.01164	0.00757	135.72240	0.00268	0.00023	135.85079
CNG	Methane	195	1.54791	0.65169	0.99099	0.00070	0.01170	0.00761	136.42200	0.00269	0.00023	136.55105
CNG	Methane	196	1.55585	0.65503	0.99607	0.00071	0.01176	0.00764	137.12160	0.00270	0.00024	137.25131
CNG	Methane	197	1.56379	0.65837	1.00115	0.00071	0.01182	0.00768	137.82120	0.00272	0.00024	137.95157
CNG	Methane	198	1.57172	0.66172	1.00624	0.00071	0.01188	0.00772	138.52080	0.00273	0.00024	138.65184
CNG	Methane	199	1.57966	0.66506	1.01132	0.00072	0.01194	0.00776	139.22040	0.00275	0.00024	139.35210
CNG	Methane	200	1.58760	0.66840	1.01640	0.00072	0.01200	0.00780	139.92000	0.00276	0.00024	140.05236
LPG	Propane	10	0.07938	0.03342	0.05082	0.00004	0.00060	0.00039	8.23200	0.00001	0.00002	8.23771
LPG	Propane	11	0.08732	0.03676	0.05590	0.00004	0.00066	0.00043	9.05520	0.00001	0.00002	9.06148
LPG	Propane	12	0.09526	0.04010	0.06098	0.00004	0.00072	0.00047	9.87840	0.00001	0.00002	9.88525
LPG	Propane	13	0.10319	0.04345	0.06607	0.00005	0.00078	0.00051	10.70160	0.00001	0.00002	10.70902
LPG	Propane	14	0.11113	0.04679	0.07115	0.00005	0.00084	0.00055	11.52480	0.00001	0.00003	11.53279
LPG	Propane	15	0.11907	0.05013	0.07623	0.00005	0.00090	0.00059	12.34800	0.00001	0.00003	12.35656
LPG	Propane	16	0.12701	0.05347	0.08131	0.00006	0.00096	0.00062	13.17120	0.00001	0.00003	13.18033
LPG	Propane	17	0.13495	0.05681	0.08639	0.00006	0.00102	0.00066	13.99440	0.00001	0.00003	14.00410
LPG	Propane	18	0.14288	0.06016	0.09148	0.00006	0.00108	0.00070	14.81760	0.00001	0.00003	14.82787
LPG	Propane	19	0.15082	0.06350	0.09656	0.00007	0.00114	0.00074	15.64080	0.00001	0.00003	15.65164
LPG	Propane	20	0.15876	0.06684	0.10164	0.00007	0.00120	0.00078	16.46400	0.00001	0.00004	16.47541
LPG	Propane	21	0.16670	0.07018	0.10672	0.00008	0.00126	0.00082	17.28720	0.00001	0.00004	17.29918
LPG	Propane	22	0.17464	0.07352	0.11180	0.00008	0.00132	0.00086	18.11040	0.00001	0.00004	18.12295
LPG	Propane	23	0.18257	0.07687	0.11689	0.00008	0.00138	0.00090	18.93360	0.00001	0.00004	18.94672
LPG	Propane	24	0.19051	0.08021	0.12197	0.00009	0.00144	0.00094	19.75680	0.00001	0.00004	19.77049
LPG	Propane	25	0.19845	0.08355	0.12705	0.00009	0.00150	0.00098	20.58000	0.00002	0.00005	20.59427
LPG	Propane	26	0.20639	0.08689	0.13213	0.00009	0.00156	0.00101	21.40320	0.00002	0.00005	21.41804
LPG	Propane	27	0.21433	0.09023	0.13721	0.00010	0.00162	0.00105	22.22640	0.00002	0.00005	22.24181
LPG	Propane	28	0.22226	0.09358	0.14230	0.00010	0.00168	0.00109	23.04960	0.00002	0.00005	23.06558
LPG	Propane	29	0.23020	0.09692	0.14738	0.00010	0.00174	0.00113	23.87280	0.00002	0.00005	23.88935
LPG	Propane	30	0.23814	0.10026	0.15246	0.00011	0.00180	0.00117	24.69600	0.00002	0.00005	24.71312
LPG	Propane	31	0.24608	0.10360	0.15754	0.00011	0.00186	0.00121	25.51920	0.00002	0.00006	25.53689
LPG	Propane	32	0.25402	0.10694	0.16262	0.00012	0.00192	0.00125	26.34240	0.00002	0.00006	26.36066
LPG	Propane	33	0.26195	0.11029	0.16771	0.00012	0.00198	0.00129	27.16560	0.00002	0.00006	27.18443
LPG	Propane	34	0.26989	0.11363	0.17279	0.00012	0.00204	0.00133	27.98880	0.00002	0.00006	28.00820
LPG	Propane	35	0.27783	0.11697	0.17787	0.00013	0.00210	0.00137	28.81200	0.00002	0.00006	28.83197
LPG	Propane	36	0.28577	0.12031	0.18295	0.00013	0.00216	0.00140	29.63520	0.00002	0.00006	29.65574
LPG	Propane	37	0.29371	0.12365	0.18803	0.00013	0.00222	0.00144	30.45840	0.00002	0.00007	30.47951
LPG	Propane	38	0.30164	0.12700	0.19312	0.00014	0.00228	0.00148	31.28160	0.00002	0.00007	31.30328
LPG	Propane	39	0.30958	0.13034	0.19820	0.00014	0.00234	0.00152	32.10480	0.00002	0.00007	32.12705
LPG	Propane	40	0.31752	0.13368	0.20328	0.00014	0.00240	0.00156	32.92800	0.00002	0.00007	32.95082
LPG	Propane	41	0.32546	0.13702	0.20836	0.00015	0.00246	0.00160	33.75120	0.00002	0.00007	33.77459
LPG	Propane	42	0.33340	0.14036	0.21344	0.00015	0.00252	0.00164	34.57440	0.00003	0.00008	34.59837
LPG	Propane	43	0.34133	0.14371	0.21853	0.00015	0.00258	0.00168	35.39760	0.00003	0.00008	35.42214
LPG	Propane	44	0.34927	0.14705	0.22361	0.00016	0.00264	0.00172	36.22080	0.00003	0.00008	36.24591
LPG	Propane	45	0.35721	0.15039	0.22869	0.00016	0.00270	0.00176	37.04400	0.00003	0.00008	37.06968
LPG	Propane	46	0.36515	0.15373	0.23377	0.00017	0.00276	0.00179	37.86720	0.00003	0.00008	37.89345
LPG	Propane	47	0.37309	0.15707	0.23885	0.00017	0.00282	0.00183	38.69040	0.00003	0.00008	38.71722
LPG	Propane	48	0.38102	0.16042	0.24394	0.00017	0.00288	0.00187	39.51360	0.00003	0.00009	39.54099
LPG	Propane	49	0.38896	0.16376	0.24902	0.00018	0.00294	0.00191	40.33680	0.00003	0.00009	40.36476
LPG	Propane	50	0.39690	0.16710	0.25410	0.00018	0.00300	0.00195	41.16000	0.00003	0.00009	41.18853
LPG	Propane	51	0.40484	0.17044	0.25918	0.00018	0.00306	0.00199	41.98320	0.00003	0.00009	42.01230
LPG	Propane	52	0.41278	0.17378	0.26426	0.00019	0.00312	0.00203	42.80640	0.00003	0.00009	42.83607
LPG	Propane	53	0.42071	0.17713	0.26935	0.00019	0.00318	0.00207	43.62960	0.00003	0.00010	43.65984
LPG	Propane	54	0.42865	0.18047	0.27443	0.00019	0.00324	0.00211	44.45280	0.00003	0.00010	44.48361
LPG	Propane	55	0.43659	0.18381	0.27951	0.00020	0.00330	0.00215	45.27600	0.00003	0.00010	45.30738
LPG	Propane	56	0.44453	0.18715	0.28459	0.00020	0.00336	0.00218	46.09920	0.00003	0.00010	46.13115
LPG	Propane	57	0.45247	0.19049	0.28967	0.00021	0.00342	0.00222	46.92240	0.00003	0.00010	46.95492
LPG	Propane	58	0.46040	0.19384	0.29476	0.00021	0.00348	0.00226	47.74560	0.00003	0.00010	47.77869
LPG	Propane	59	0.46834	0.19718	0.29984	0.00021	0.00354	0.00230	48.56880	0.00004	0.00011	48.60247
LPG	Propane	60	0.47628	0.20052	0.30492	0.00022	0.00360	0.00234	49.39200	0.00004	0.00011	49.42624
LPG	Propane	61	0.48422	0.20386	0.31000	0.00022	0.00366	0.00238	50.21520	0.00004	0.00011	50.25001
LPG	Propane	62	0.49216	0.20720	0.31508	0.00022	0.00372	0.00242	51.03840	0.00004	0.00011	51.07378
LPG	Propane	63	0.50009	0.21055	0.32017	0.00023	0.00378	0.00246	51.86160	0.00004	0.00011	51.89755
LPG	Propane	64	0.50803	0.21389	0.32525	0.00023	0.00384	0.00250	52.68480	0.00004	0.00012	52.72132
LPG	Propane	65	0.51597	0.21723	0.33033	0.00023	0.00390	0.00254	53.50800	0.00004	0.00012	53.54509
LPG	Propane	66	0.52391	0.22057	0.33541	0.00024	0.00396	0.00257	54.33120	0.00004	0.00012	54.36886
LPG	Propane	67	0.53185	0.22391	0.34049	0.00024	0.00402	0.00261	55.15440	0.00004	0.00012	55.19263
LPG	Propane	68	0.53978	0.22726	0.34558	0.00024	0.00408	0.00265	55.97760	0.00004	0.00012	56.01640
LPG	Propane	69	0.54772	0.23060	0.35066	0.00025	0.00414	0.00269	56.80080	0.00004	0.00012	56.84017
LPG	Propane	70	0.55566	0.23394	0.35574	0.00025	0.00420	0.00273	57.62400	0.00004	0.00013	57.66394
LPG	Propane	71	0.56360	0.23728	0.36082	0.00026	0.00426	0.00277	58.44720	0.00004	0.00013	58.48771
LPG	Propane	72	0.57154	0.24062	0.36590	0.00026	0.00432	0.00281	59.27040	0.00004	0.00013	59.31148

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
LPG	Propane	73	0.57947	0.24397	0.37099	0.00026	0.00438	0.00285	60.09360	0.00004	0.00013	60.13525
LPG	Propane	74	0.58741	0.24731	0.37607	0.00027	0.00444	0.00289	60.91680	0.00004	0.00013	60.95902
LPG	Propane	75	0.59535	0.25065	0.38115	0.00027	0.00450	0.00293	61.74000	0.00005	0.00014	61.78280
LPG	Propane	76	0.60329	0.25399	0.38623	0.00027	0.00456	0.00296	62.56320	0.00005	0.00014	62.60657
LPG	Propane	77	0.61123	0.25733	0.39131	0.00028	0.00462	0.00300	63.38640	0.00005	0.00014	63.43034
LPG	Propane	78	0.61916	0.26068	0.39640	0.00028	0.00468	0.00304	64.20960	0.00005	0.00014	64.25411
LPG	Propane	79	0.62710	0.26402	0.40148	0.00028	0.00474	0.00308	65.03280	0.00005	0.00014	65.07788
LPG	Propane	80	0.63504	0.26736	0.40656	0.00029	0.00480	0.00312	65.85600	0.00005	0.00014	65.90165
LPG	Propane	81	0.64298	0.27070	0.41164	0.00029	0.00486	0.00316	66.67920	0.00005	0.00015	66.72542
LPG	Propane	82	0.65092	0.27404	0.41672	0.00030	0.00492	0.00320	67.50240	0.00005	0.00015	67.54919
LPG	Propane	83	0.65885	0.27739	0.42181	0.00030	0.00498	0.00324	68.32560	0.00005	0.00015	68.37296
LPG	Propane	84	0.66679	0.28073	0.42689	0.00030	0.00504	0.00328	69.14880	0.00005	0.00015	69.19673
LPG	Propane	85	0.67473	0.28407	0.43197	0.00031	0.00510	0.00332	69.97200	0.00005	0.00015	70.02050
LPG	Propane	86	0.68267	0.28741	0.43705	0.00031	0.00516	0.00335	70.79520	0.00005	0.00015	70.84427
LPG	Propane	87	0.69061	0.29075	0.44213	0.00031	0.00522	0.00339	71.61840	0.00005	0.00016	71.66804
LPG	Propane	88	0.69854	0.29410	0.44722	0.00032	0.00528	0.00343	72.44160	0.00005	0.00016	72.49181
LPG	Propane	89	0.70648	0.29744	0.45230	0.00032	0.00534	0.00347	73.26480	0.00005	0.00016	73.31558
LPG	Propane	90	0.71442	0.30078	0.45738	0.00032	0.00540	0.00351	74.08800	0.00005	0.00016	74.13935
LPG	Propane	91	0.72236	0.30412	0.46246	0.00033	0.00546	0.00355	74.91120	0.00005	0.00016	74.96312
LPG	Propane	92	0.73030	0.30746	0.46754	0.00033	0.00552	0.00359	75.73440	0.00006	0.00017	75.78690
LPG	Propane	93	0.73823	0.31081	0.47263	0.00033	0.00558	0.00363	76.55760	0.00006	0.00017	76.61067
LPG	Propane	94	0.74617	0.31415	0.47771	0.00034	0.00564	0.00367	77.38080	0.00006	0.00017	77.43444
LPG	Propane	95	0.75411	0.31749	0.48279	0.00034	0.00570	0.00371	78.20400	0.00006	0.00017	78.25821
LPG	Propane	96	0.76205	0.32083	0.48787	0.00035	0.00576	0.00374	79.02720	0.00006	0.00017	79.08198
LPG	Propane	97	0.76999	0.32417	0.49295	0.00035	0.00582	0.00378	79.85040	0.00006	0.00017	79.90575
LPG	Propane	98	0.77792	0.32752	0.49804	0.00035	0.00588	0.00382	80.67360	0.00006	0.00018	80.72952
LPG	Propane	99	0.78586	0.33086	0.50312	0.00036	0.00594	0.00386	81.49680	0.00006	0.00018	81.55329
LPG	Propane	100	0.79380	0.33420	0.50820	0.00036	0.00600	0.00390	82.32000	0.00006	0.00018	82.37706
LPG	Propane	101	0.80174	0.33754	0.51328	0.00036	0.00606	0.00394	83.14320	0.00006	0.00018	83.20083
LPG	Propane	102	0.80968	0.34088	0.51836	0.00037	0.00612	0.00398	83.96640	0.00006	0.00018	84.02460
LPG	Propane	103	0.81761	0.34423	0.52345	0.00037	0.00618	0.00402	84.78960	0.00006	0.00019	84.84837
LPG	Propane	104	0.82555	0.34757	0.52853	0.00037	0.00624	0.00406	85.61280	0.00006	0.00019	85.67214
LPG	Propane	105	0.83349	0.35091	0.53361	0.00038	0.00630	0.00410	86.43600	0.00006	0.00019	86.49591
LPG	Propane	106	0.84143	0.35425	0.53869	0.00038	0.00636	0.00413	87.25920	0.00006	0.00019	87.31968
LPG	Propane	107	0.84937	0.35759	0.54377	0.00039	0.00642	0.00417	88.08240	0.00006	0.00019	88.14345
LPG	Propane	108	0.85730	0.36094	0.54886	0.00039	0.00648	0.00421	88.90560	0.00006	0.00019	88.96722
LPG	Propane	109	0.86524	0.36428	0.55394	0.00039	0.00654	0.00425	89.72880	0.00007	0.00020	89.79100
LPG	Propane	110	0.87318	0.36762	0.55902	0.00040	0.00660	0.00429	90.55200	0.00007	0.00020	90.61477
LPG	Propane	111	0.88112	0.37096	0.56410	0.00040	0.00666	0.00433	91.37520	0.00007	0.00020	91.43854
LPG	Propane	112	0.88906	0.37430	0.56918	0.00040	0.00672	0.00437	92.19840	0.00007	0.00020	92.26231
LPG	Propane	113	0.89699	0.37765	0.57427	0.00041	0.00678	0.00441	93.02160	0.00007	0.00020	93.08608
LPG	Propane	114	0.90493	0.38099	0.57935	0.00041	0.00684	0.00445	93.84480	0.00007	0.00021	93.90985
LPG	Propane	115	0.91287	0.38433	0.58443	0.00041	0.00690	0.00449	94.66800	0.00007	0.00021	94.73362
LPG	Propane	116	0.92081	0.38767	0.58951	0.00042	0.00696	0.00452	95.49120	0.00007	0.00021	95.55739
LPG	Propane	117	0.92875	0.39101	0.59459	0.00042	0.00702	0.00456	96.31440	0.00007	0.00021	96.38116
LPG	Propane	118	0.93668	0.39436	0.59968	0.00042	0.00708	0.00460	97.13760	0.00007	0.00021	97.20493
LPG	Propane	119	0.94462	0.39770	0.60476	0.00043	0.00714	0.00464	97.96080	0.00007	0.00021	98.02870
LPG	Propane	120	0.95256	0.40104	0.60984	0.00043	0.00720	0.00468	98.78400	0.00007	0.00022	98.85247
LPG	Propane	121	0.96050	0.40438	0.61492	0.00044	0.00726	0.00472	99.60720	0.00007	0.00022	99.67624
LPG	Propane	122	0.96844	0.40772	0.62000	0.00044	0.00732	0.00476	100.43040	0.00007	0.00022	100.50001
LPG	Propane	123	0.97637	0.41107	0.62509	0.00044	0.00738	0.00480	101.25360	0.00007	0.00022	101.32378
LPG	Propane	124	0.98431	0.41441	0.63017	0.00045	0.00744	0.00484	102.07680	0.00007	0.00022	102.14755
LPG	Propane	125	0.99225	0.41775	0.63525	0.00045	0.00750	0.00488	102.90000	0.00008	0.00023	102.97133
LPG	Propane	126	1.00019	0.42109	0.64033	0.00045	0.00756	0.00491	103.72320	0.00008	0.00023	103.79510
LPG	Propane	127	1.00813	0.42443	0.64541	0.00046	0.00762	0.00495	104.54640	0.00008	0.00023	104.61887
LPG	Propane	128	1.01606	0.42778	0.65050	0.00046	0.00768	0.00499	105.36960	0.00008	0.00023	105.44264
LPG	Propane	129	1.02400	0.43112	0.65558	0.00046	0.00774	0.00503	106.19280	0.00008	0.00023	106.26641
LPG	Propane	130	1.03194	0.43446	0.66066	0.00047	0.00780	0.00507	107.01600	0.00008	0.00023	107.09018
LPG	Propane	131	1.03988	0.43780	0.66574	0.00047	0.00786	0.00511	107.83920	0.00008	0.00024	107.91395
LPG	Propane	132	1.04782	0.44114	0.67082	0.00048	0.00792	0.00515	108.66240	0.00008	0.00024	108.73772
LPG	Propane	133	1.05575	0.44449	0.67591	0.00048	0.00798	0.00519	109.48560	0.00008	0.00024	109.56149
LPG	Propane	134	1.06369	0.44783	0.68099	0.00048	0.00804	0.00523	110.30880	0.00008	0.00024	110.38526
LPG	Propane	135	1.07163	0.45117	0.68607	0.00049	0.00810	0.00527	111.13200	0.00008	0.00024	111.20903
LPG	Propane	136	1.07957	0.45451	0.69115	0.00049	0.00816	0.00530	111.95520	0.00008	0.00024	112.03280
LPG	Propane	137	1.08751	0.45785	0.69623	0.00049	0.00822	0.00534	112.77840	0.00008	0.00025	112.85657
LPG	Propane	138	1.09544	0.46120	0.70132	0.00050	0.00828	0.00538	113.60160	0.00008	0.00025	113.68034
LPG	Propane	139	1.10338	0.46454	0.70640	0.00050	0.00834	0.00542	114.42480	0.00008	0.00025	114.50411
LPG	Propane	140	1.11132	0.46788	0.71148	0.00050	0.00840	0.00546	115.24800	0.00008	0.00025	115.32788
LPG	Propane	141	1.11926	0.47122	0.71656	0.00051	0.00846	0.00550	116.07120	0.00008	0.00025	116.15165
LPG	Propane	142	1.12720	0.47456	0.72164	0.00051	0.00852	0.00554	116.89440	0.00009	0.00026	116.97543
LPG	Propane	143	1.13513	0.47791	0.72673	0.00051	0.00858	0.00558	117.71760	0.00009	0.00026	117.79920
LPG	Propane	144	1.14307	0.48125	0.73181	0.00052	0.00864	0.00562	118.54080	0.00009	0.00026	118.62297
LPG	Propane	145	1.15101	0.48459	0.73689	0.00052	0.00870	0.00566	119.36400	0.00009	0.00026	119.44674
LPG	Propane	146	1.15895	0.48793	0.74197	0.00053	0.00876	0.00569	120.18720	0.00009	0.00026	120.27051
LPG	Propane	147	1.16689	0.49127	0.74705	0.00053	0.00882	0.00573	121.01040	0.00009	0.00026	121.09428
LPG	Propane	148	1.17482	0.49462	0.75214	0.00053	0.00888	0.00577	121.83360	0.00009	0.00027	121.91805
LPG	Propane	149	1.18276	0.49796	0.75722	0.00054	0.00894	0.00581	122.65680	0.00009	0.00027	122.74182
LPG	Propane	150	1.19070	0.50130	0.76230	0.00054	0.00900	0.00585	123.48000	0.00009	0.00027	123.56559

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
LPG	Propane	151	1.19864	0.50464	0.76738	0.00054	0.00906	0.00589	124.30320	0.00009	0.00027	124.38936
LPG	Propane	152	1.20658	0.50798	0.77246	0.00055	0.00912	0.00593	125.12640	0.00009	0.00027	125.21313
LPG	Propane	153	1.21451	0.51133	0.77755	0.00055	0.00918	0.00597	125.94960	0.00009	0.00028	126.03690
LPG	Propane	154	1.22245	0.51467	0.78263	0.00055	0.00924	0.00601	126.77280	0.00009	0.00028	126.86067
LPG	Propane	155	1.23039	0.51801	0.78771	0.00056	0.00930	0.00605	127.59600	0.00009	0.00028	127.68444
LPG	Propane	156	1.23833	0.52135	0.79279	0.00056	0.00936	0.00608	128.41920	0.00009	0.00028	128.50821
LPG	Propane	157	1.24627	0.52469	0.79787	0.00057	0.00942	0.00612	129.24240	0.00009	0.00028	129.33198
LPG	Propane	158	1.25420	0.52804	0.80296	0.00057	0.00948	0.00616	130.06560	0.00009	0.00028	130.15575
LPG	Propane	159	1.26214	0.53138	0.80804	0.00057	0.00954	0.00620	130.88880	0.00010	0.00029	130.97953
LPG	Propane	160	1.27008	0.53472	0.81312	0.00058	0.00960	0.00624	131.71200	0.00010	0.00029	131.80330
LPG	Propane	161	1.27802	0.53806	0.81820	0.00058	0.00966	0.00628	132.53520	0.00010	0.00029	132.62707
LPG	Propane	162	1.28596	0.54140	0.82328	0.00058	0.00972	0.00632	133.35840	0.00010	0.00029	133.45084
LPG	Propane	163	1.29389	0.54475	0.82837	0.00059	0.00978	0.00636	134.18160	0.00010	0.00029	134.27461
LPG	Propane	164	1.30183	0.54809	0.83345	0.00059	0.00984	0.00640	135.00480	0.00010	0.00030	135.09838
LPG	Propane	165	1.30977	0.55143	0.83853	0.00059	0.00990	0.00644	135.82800	0.00010	0.00030	135.92215
LPG	Propane	166	1.31771	0.55477	0.84361	0.00060	0.00996	0.00647	136.65120	0.00010	0.00030	136.74592
LPG	Propane	167	1.32565	0.55811	0.84869	0.00060	0.01002	0.00651	137.47440	0.00010	0.00030	137.56969
LPG	Propane	168	1.33358	0.56146	0.85378	0.00060	0.01008	0.00655	138.29760	0.00010	0.00030	138.39346
LPG	Propane	169	1.34152	0.56480	0.85886	0.00061	0.01014	0.00659	139.12080	0.00010	0.00030	139.21723
LPG	Propane	170	1.34946	0.56814	0.86394	0.00061	0.01020	0.00663	139.94400	0.00010	0.00031	140.04100
LPG	Propane	171	1.35740	0.57148	0.86902	0.00062	0.01026	0.00667	140.76720	0.00010	0.00031	140.86477
LPG	Propane	172	1.36534	0.57482	0.87410	0.00062	0.01032	0.00671	141.59040	0.00010	0.00031	141.68854
LPG	Propane	173	1.37327	0.57817	0.87919	0.00062	0.01038	0.00675	142.41360	0.00010	0.00031	142.51231
LPG	Propane	174	1.38121	0.58151	0.88427	0.00063	0.01044	0.00679	143.23680	0.00010	0.00031	143.33608
LPG	Propane	175	1.38915	0.58485	0.88935	0.00063	0.01050	0.00683	144.06000	0.00011	0.00032	144.15986
LPG	Propane	176	1.39709	0.58819	0.89443	0.00063	0.01056	0.00686	144.88320	0.00011	0.00032	144.98363
LPG	Propane	177	1.40503	0.59153	0.89951	0.00064	0.01062	0.00690	145.70640	0.00011	0.00032	145.80740
LPG	Propane	178	1.41296	0.59488	0.90460	0.00064	0.01068	0.00694	146.52960	0.00011	0.00032	146.63117
LPG	Propane	179	1.42090	0.59822	0.90968	0.00064	0.01074	0.00698	147.35280	0.00011	0.00032	147.45494
LPG	Propane	180	1.42884	0.60156	0.91476	0.00065	0.01080	0.00702	148.17600	0.00011	0.00032	148.27871
LPG	Propane	181	1.43678	0.60490	0.91984	0.00065	0.01086	0.00706	148.99920	0.00011	0.00033	149.10248
LPG	Propane	182	1.44472	0.60824	0.92492	0.00066	0.01092	0.00710	149.82240	0.00011	0.00033	149.92625
LPG	Propane	183	1.45265	0.61159	0.93001	0.00066	0.01098	0.00714	150.64560	0.00011	0.00033	150.75002
LPG	Propane	184	1.46059	0.61493	0.93509	0.00066	0.01104	0.00718	151.46880	0.00011	0.00033	151.57379
LPG	Propane	185	1.46853	0.61827	0.94017	0.00067	0.01110	0.00722	152.29200	0.00011	0.00033	152.39756
LPG	Propane	186	1.47647	0.62161	0.94525	0.00067	0.01116	0.00725	153.11520	0.00011	0.00033	153.22133
LPG	Propane	187	1.48441	0.62495	0.95033	0.00067	0.01122	0.00729	153.93840	0.00011	0.00034	154.04510
LPG	Propane	188	1.49234	0.62830	0.95542	0.00068	0.01128	0.00733	154.76160	0.00011	0.00034	154.86887
LPG	Propane	189	1.50028	0.63164	0.96050	0.00068	0.01134	0.00737	155.58480	0.00011	0.00034	155.69264
LPG	Propane	190	1.50822	0.63498	0.96558	0.00068	0.01140	0.00741	156.40800	0.00011	0.00034	156.51641
LPG	Propane	191	1.51616	0.63832	0.97066	0.00069	0.01146	0.00745	157.23120	0.00011	0.00034	157.34018
LPG	Propane	192	1.52410	0.64166	0.97574	0.00069	0.01152	0.00749	158.05440	0.00012	0.00035	158.16396
LPG	Propane	193	1.53203	0.64501	0.98083	0.00069	0.01158	0.00753	158.87760	0.00012	0.00035	158.98773
LPG	Propane	194	1.53997	0.64835	0.98591	0.00070	0.01164	0.00757	159.70080	0.00012	0.00035	159.81150
LPG	Propane	195	1.54791	0.65169	0.99099	0.00070	0.01170	0.00761	160.52400	0.00012	0.00035	160.63527
LPG	Propane	196	1.55585	0.65503	0.99607	0.00071	0.01176	0.00764	161.34720	0.00012	0.00035	161.45904
LPG	Propane	197	1.56379	0.65837	1.00115	0.00071	0.01182	0.00768	162.17040	0.00012	0.00035	162.28281
LPG	Propane	198	1.57172	0.66172	1.00624	0.00071	0.01188	0.00772	162.99360	0.00012	0.00036	163.10658
LPG	Propane	199	1.57966	0.66506	1.01132	0.00072	0.01194	0.00776	163.81680	0.00012	0.00036	163.93035
LPG	Propane	200	1.58760	0.66840	1.01640	0.00072	0.01200	0.00780	164.64000	0.00012	0.00036	164.75412
Gasoline	**Sport**	**10**	**0.05670**	**1.88100**	**0.04890**	**0.00252**	**0.00300**	**0.00195**	**4.71900**	**0.00027**	**0.00012**	**4.76088**
Gasoline	Sport	11	0.06237	2.06910	0.05379	0.00277	0.00330	0.00215	5.19090	0.00029	0.00013	5.23696
Gasoline	Sport	12	0.06804	2.25720	0.05868	0.00302	0.00360	0.00234	5.66280	0.00032	0.00014	5.71305
Gasoline	Sport	13	0.07371	2.44530	0.06357	0.00328	0.00390	0.00254	6.13470	0.00035	0.00015	6.18914
Gasoline	Sport	14	0.07938	2.63340	0.06846	0.00353	0.00420	0.00273	6.60660	0.00037	0.00016	6.66523
Gasoline	Sport	15	0.08505	2.82150	0.07335	0.00378	0.00450	0.00293	7.07850	0.00040	0.00018	7.14132
Gasoline	Sport	16	0.09072	3.00960	0.07824	0.00403	0.00480	0.00312	7.55040	0.00043	0.00019	7.61740
Gasoline	Sport	17	0.09639	3.19770	0.08313	0.00428	0.00510	0.00332	8.02230	0.00045	0.00020	8.09349
Gasoline	Sport	18	0.10206	3.38580	0.08802	0.00454	0.00540	0.00351	8.49420	0.00048	0.00021	8.56958
Gasoline	Sport	19	0.10773	3.57390	0.09291	0.00479	0.00570	0.00371	8.96610	0.00051	0.00022	9.04567
Gasoline	Sport	20	0.11340	3.76200	0.09780	0.00504	0.00600	0.00390	9.43800	0.00053	0.00023	9.52175
Gasoline	Sport	21	0.11907	3.95010	0.10269	0.00529	0.00630	0.00410	9.90990	0.00056	0.00025	9.99784
Gasoline	Sport	22	0.12474	4.13820	0.10758	0.00554	0.00660	0.00429	10.38180	0.00059	0.00026	10.47393
Gasoline	Sport	23	0.13041	4.32630	0.11247	0.00580	0.00690	0.00449	10.85370	0.00061	0.00027	10.95002
Gasoline	Sport	24	0.13608	4.51440	0.11736	0.00605	0.00720	0.00468	11.32560	0.00064	0.00028	11.42610
Gasoline	Sport	25	0.14175	4.70250	0.12225	0.00630	0.00750	0.00488	11.79750	0.00067	0.00029	11.90219
Gasoline	Sport	26	0.14742	4.89060	0.12714	0.00655	0.00780	0.00507	12.26940	0.00069	0.00030	12.37828
Gasoline	Sport	27	0.15309	5.07870	0.13203	0.00680	0.00810	0.00527	12.74130	0.00072	0.00032	12.85437
Gasoline	Sport	28	0.15876	5.26680	0.13692	0.00706	0.00840	0.00546	13.21320	0.00075	0.00033	13.33046
Gasoline	Sport	29	0.16443	5.45490	0.14181	0.00731	0.00870	0.00566	13.68510	0.00077	0.00034	13.80654
Gasoline	Sport	30	0.17010	5.64300	0.14670	0.00756	0.00900	0.00585	14.15700	0.00080	0.00035	14.28263
Gasoline	Sport	31	0.17577	5.83110	0.15159	0.00781	0.00930	0.00605	14.62890	0.00083	0.00036	14.75872
Gasoline	Sport	32	0.18144	6.01920	0.15648	0.00806	0.00960	0.00624	15.10080	0.00085	0.00037	15.23481
Gasoline	Sport	33	0.18711	6.20730	0.16137	0.00832	0.00990	0.00644	15.57270	0.00088	0.00039	15.71089
Gasoline	Sport	34	0.19278	6.39540	0.16626	0.00857	0.01020	0.00663	16.04460	0.00091	0.00040	16.18698
Gasoline	Sport	35	0.19845	6.58350	0.17115	0.00882	0.01050	0.00683	16.51650	0.00093	0.00041	16.66307
Gasoline	Sport	36	0.20412	6.77160	0.17604	0.00907	0.01080	0.00702	16.98840	0.00096	0.00042	17.13916
Gasoline	Sport	37	0.20979	6.95970	0.18093	0.00932	0.01110	0.00722	17.46030	0.00099	0.00043	17.61524

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
Gasoline	Sport	38	0.21546	7.14780	0.18582	0.00958	0.01140	0.00741	17.93220	0.00101	0.00044	18.09133
Gasoline	Sport	39	0.22113	7.33590	0.19071	0.00983	0.01170	0.00761	18.40410	0.00104	0.00046	18.56742
Gasoline	Sport	40	0.22680	7.52400	0.19560	0.01008	0.01200	0.00780	18.87600	0.00107	0.00047	19.04351
Gasoline	Sport	41	0.23247	7.71210	0.20049	0.01033	0.01230	0.00800	19.34790	0.00109	0.00048	19.51960
Gasoline	Sport	42	0.23814	7.90020	0.20538	0.01058	0.01260	0.00819	19.81980	0.00112	0.00049	19.99568
Gasoline	Sport	43	0.24381	8.08830	0.21027	0.01084	0.01290	0.00839	20.29170	0.00115	0.00050	20.47177
Gasoline	Sport	44	0.24948	8.27640	0.21516	0.01109	0.01320	0.00858	20.76360	0.00117	0.00051	20.94786
Gasoline	Sport	45	0.25515	8.46450	0.22005	0.01134	0.01350	0.00878	21.23550	0.00120	0.00053	21.42395
Gasoline	Sport	46	0.26082	8.65260	0.22494	0.01159	0.01380	0.00897	21.70740	0.00123	0.00054	21.90003
Gasoline	Sport	47	0.26649	8.84070	0.22983	0.01184	0.01410	0.00917	22.17930	0.00125	0.00055	22.37612
Gasoline	Sport	48	0.27216	9.02880	0.23472	0.01210	0.01440	0.00936	22.65120	0.00128	0.00056	22.85221
Gasoline	Sport	49	0.27783	9.21690	0.23961	0.01235	0.01470	0.00956	23.12310	0.00131	0.00057	23.32830
Gasoline	Sport	50	0.28350	9.40500	0.24450	0.01260	0.01500	0.00975	23.59500	0.00134	0.00059	23.80439
Gasoline	Sport	51	0.28917	9.59310	0.24939	0.01285	0.01530	0.00995	24.06690	0.00136	0.00060	24.28047
Gasoline	Sport	52	0.29484	9.78120	0.25428	0.01310	0.01560	0.01014	24.53880	0.00139	0.00061	24.75656
Gasoline	Sport	53	0.30051	9.96930	0.25917	0.01336	0.01590	0.01034	25.01070	0.00142	0.00062	25.23265
Gasoline	Sport	54	0.30618	10.15740	0.26406	0.01361	0.01620	0.01053	25.48260	0.00144	0.00063	25.70874
Gasoline	Sport	55	0.31185	10.34550	0.26895	0.01386	0.01650	0.01073	25.95450	0.00147	0.00064	26.18482
Gasoline	Sport	56	0.31752	10.53360	0.27384	0.01411	0.01680	0.01092	26.42640	0.00150	0.00066	26.66091
Gasoline	Sport	57	0.32319	10.72170	0.27873	0.01436	0.01710	0.01112	26.89830	0.00152	0.00067	27.13700
Gasoline	Sport	58	0.32886	10.90980	0.28362	0.01462	0.01740	0.01131	27.37020	0.00155	0.00068	27.61309
Gasoline	Sport	59	0.33453	11.09790	0.28851	0.01487	0.01770	0.01151	27.84210	0.00158	0.00069	28.08917
Gasoline	Sport	60	0.34020	11.28600	0.29340	0.01512	0.01800	0.01170	28.31400	0.00160	0.00070	28.56526
Gasoline	Sport	61	0.34587	11.47410	0.29829	0.01537	0.01830	0.01190	28.78590	0.00163	0.00071	29.04135
Gasoline	Sport	62	0.35154	11.66220	0.30318	0.01562	0.01860	0.01209	29.25780	0.00166	0.00073	29.51744
Gasoline	Sport	63	0.35721	11.85030	0.30807	0.01588	0.01890	0.01229	29.72970	0.00168	0.00074	29.99353
Gasoline	Sport	64	0.36288	12.03840	0.31296	0.01613	0.01920	0.01248	30.20160	0.00171	0.00075	30.46961
Gasoline	Sport	65	0.36855	12.22650	0.31785	0.01638	0.01950	0.01268	30.67350	0.00174	0.00076	30.94570
Gasoline	Sport	66	0.37422	12.41460	0.32274	0.01663	0.01980	0.01287	31.14540	0.00176	0.00077	31.42179
Gasoline	Sport	67	0.37989	12.60270	0.32763	0.01688	0.02010	0.01307	31.61730	0.00179	0.00078	31.89788
Gasoline	Sport	68	0.38556	12.79080	0.33252	0.01714	0.02040	0.01326	32.08920	0.00182	0.00080	32.37396
Gasoline	Sport	69	0.39123	12.97890	0.33741	0.01739	0.02070	0.01346	32.56110	0.00184	0.00081	32.85005
Gasoline	Sport	70	0.39690	13.16700	0.34230	0.01764	0.02100	0.01365	33.03300	0.00187	0.00082	33.32614
Gasoline	Sport	71	0.40257	13.35510	0.34719	0.01789	0.02130	0.01385	33.50490	0.00190	0.00083	33.80223
Gasoline	Sport	72	0.40824	13.54320	0.35208	0.01814	0.02160	0.01404	33.97680	0.00192	0.00084	34.27831
Gasoline	Sport	73	0.41391	13.73130	0.35697	0.01840	0.02190	0.01424	34.44870	0.00195	0.00085	34.75440
Gasoline	Sport	74	0.41958	13.91940	0.36186	0.01865	0.02220	0.01443	34.92060	0.00198	0.00087	35.23049
Gasoline	Sport	75	0.42525	14.10750	0.36675	0.01890	0.02250	0.01463	35.39250	0.00200	0.00088	35.70658
Gasoline	Sport	76	0.43092	14.29560	0.37164	0.01915	0.02280	0.01482	35.86440	0.00203	0.00089	36.18267
Gasoline	Sport	77	0.43659	14.48370	0.37653	0.01940	0.02310	0.01502	36.33630	0.00206	0.00090	36.65875
Gasoline	Sport	78	0.44226	14.67180	0.38142	0.01966	0.02340	0.01521	36.80820	0.00208	0.00091	37.13484
Gasoline	Sport	79	0.44793	14.85990	0.38631	0.01991	0.02370	0.01541	37.28010	0.00211	0.00092	37.61093
Gasoline	Sport	80	0.45360	15.04800	0.39120	0.02016	0.02400	0.01560	37.75200	0.00214	0.00094	38.08702
Gasoline	Sport	81	0.45927	15.23610	0.39609	0.02041	0.02430	0.01580	38.22390	0.00216	0.00095	38.56310
Gasoline	Sport	82	0.46494	15.42420	0.40098	0.02066	0.02460	0.01599	38.69580	0.00219	0.00096	39.03919
Gasoline	Sport	83	0.47061	15.61230	0.40587	0.02092	0.02490	0.01619	39.16770	0.00222	0.00097	39.51528
Gasoline	Sport	84	0.47628	15.80040	0.41076	0.02117	0.02520	0.01638	39.63960	0.00224	0.00098	39.99137
Gasoline	Sport	85	0.48195	15.98850	0.41565	0.02142	0.02550	0.01658	40.11150	0.00227	0.00099	40.46745
Gasoline	Sport	86	0.48762	16.17660	0.42054	0.02167	0.02580	0.01677	40.58340	0.00230	0.00101	40.94354
Gasoline	Sport	87	0.49329	16.36470	0.42543	0.02192	0.02610	0.01697	41.05530	0.00232	0.00102	41.41963
Gasoline	Sport	88	0.49896	16.55280	0.43032	0.02218	0.02640	0.01716	41.52720	0.00235	0.00103	41.89572
Gasoline	Sport	89	0.50463	16.74090	0.43521	0.02243	0.02670	0.01736	41.99910	0.00238	0.00104	42.37181
Gasoline	Sport	90	0.51030	16.92900	0.44010	0.02268	0.02700	0.01755	42.47100	0.00240	0.00105	42.84789
Gasoline	Sport	91	0.51597	17.11710	0.44499	0.02293	0.02730	0.01775	42.94290	0.00243	0.00106	43.32398
Gasoline	Sport	92	0.52164	17.30520	0.44988	0.02318	0.02760	0.01794	43.41480	0.00246	0.00108	43.80007
Gasoline	Sport	93	0.52731	17.49330	0.45477	0.02344	0.02790	0.01814	43.88670	0.00248	0.00109	44.27616
Gasoline	Sport	94	0.53298	17.68140	0.45966	0.02369	0.02820	0.01833	44.35860	0.00251	0.00110	44.75224
Gasoline	Sport	95	0.53865	17.86950	0.46455	0.02394	0.02850	0.01853	44.83050	0.00254	0.00111	45.22833
Gasoline	Sport	96	0.54432	18.05760	0.46944	0.02419	0.02880	0.01872	45.30240	0.00256	0.00112	45.70442
Gasoline	Sport	97	0.54999	18.24570	0.47433	0.02444	0.02910	0.01892	45.77430	0.00259	0.00113	46.18051
Gasoline	Sport	98	0.55566	18.43380	0.47922	0.02470	0.02940	0.01911	46.24620	0.00262	0.00115	46.65659
Gasoline	Sport	99	0.56133	18.62190	0.48411	0.02495	0.02970	0.01931	46.71810	0.00264	0.00116	47.13268
Gasoline	Sport	100	0.56700	18.81000	0.48900	0.02520	0.03000	0.01950	47.19000	0.00267	0.00117	47.60877
Gasoline	Sport	101	0.57267	18.99810	0.49389	0.02545	0.03030	0.01970	47.66190	0.00270	0.00118	48.08486
Gasoline	Sport	102	0.57834	19.18620	0.49878	0.02570	0.03060	0.01989	48.13380	0.00272	0.00119	48.56095
Gasoline	Sport	103	0.58401	19.37430	0.50367	0.02596	0.03090	0.02009	48.60570	0.00275	0.00121	49.03703
Gasoline	Sport	104	0.58968	19.56240	0.50856	0.02621	0.03120	0.02028	49.07760	0.00278	0.00122	49.51312
Gasoline	Sport	105	0.59535	19.75050	0.51345	0.02646	0.03150	0.02048	49.54950	0.00280	0.00123	49.98921
Gasoline	Sport	106	0.60102	19.93860	0.51834	0.02671	0.03180	0.02067	50.02140	0.00283	0.00124	50.46530
Gasoline	Sport	107	0.60669	20.12670	0.52323	0.02696	0.03210	0.02087	50.49330	0.00286	0.00125	50.94138
Gasoline	Sport	108	0.61236	20.31480	0.52812	0.02722	0.03240	0.02106	50.96520	0.00288	0.00126	51.41747
Gasoline	Sport	109	0.61803	20.50290	0.53301	0.02747	0.03270	0.02126	51.43710	0.00291	0.00128	51.89356
Gasoline	Sport	110	0.62370	20.69100	0.53790	0.02772	0.03300	0.02145	51.90900	0.00294	0.00129	52.36965
Gasoline	Sport	111	0.62937	20.87910	0.54279	0.02797	0.03330	0.02165	52.38090	0.00296	0.00130	52.84573
Gasoline	Sport	112	0.63504	21.06720	0.54768	0.02822	0.03360	0.02184	52.85280	0.00299	0.00131	53.32182
Gasoline	Sport	113	0.64071	21.25530	0.55257	0.02848	0.03390	0.02204	53.32470	0.00302	0.00132	53.79791
Gasoline	Sport	114	0.64638	21.44340	0.55746	0.02873	0.03420	0.02223	53.79660	0.00304	0.00133	54.27400
Gasoline	Sport	115	0.65205	21.63150	0.56235	0.02898	0.03450	0.02243	54.26850	0.00307	0.00135	54.75009

Factors

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
Gasoline	Sport	116	0.65772	21.81960	0.56724	0.02923	0.03480	0.02262	54.74040	0.00310	0.00136	55.22617
Gasoline	Sport	117	0.66339	22.00770	0.57213	0.02948	0.03510	0.02282	55.21230	0.00312	0.00137	55.70226
Gasoline	Sport	118	0.66906	22.19580	0.57702	0.02974	0.03540	0.02301	55.68420	0.00315	0.00138	56.17835
Gasoline	Sport	119	0.67473	22.38390	0.58191	0.02999	0.03570	0.02321	56.15610	0.00318	0.00139	56.65444
Gasoline	Sport	120	0.68040	22.57200	0.58680	0.03024	0.03600	0.02340	56.62800	0.00320	0.00140	57.13052
Gasoline	Sport	121	0.68607	22.76010	0.59169	0.03049	0.03630	0.02360	57.09990	0.00323	0.00142	57.60661
Gasoline	Sport	122	0.69174	22.94820	0.59658	0.03074	0.03660	0.02379	57.57180	0.00326	0.00143	58.08270
Gasoline	Sport	123	0.69741	23.13630	0.60147	0.03100	0.03690	0.02399	58.04370	0.00328	0.00144	58.55879
Gasoline	Sport	124	0.70308	23.32440	0.60636	0.03125	0.03720	0.02418	58.51560	0.00331	0.00145	59.03487
Gasoline	Sport	125	0.70875	23.51250	0.61125	0.03150	0.03750	0.02438	58.98750	0.00334	0.00146	59.51096
Gasoline	Sport	126	0.71442	23.70060	0.61614	0.03175	0.03780	0.02457	59.45940	0.00336	0.00147	59.98705
Gasoline	Sport	127	0.72009	23.88870	0.62103	0.03200	0.03810	0.02477	59.93130	0.00339	0.00149	60.46314
Gasoline	Sport	128	0.72576	24.07680	0.62592	0.03226	0.03840	0.02496	60.40320	0.00342	0.00150	60.93923
Gasoline	Sport	129	0.73143	24.26490	0.63081	0.03251	0.03870	0.02516	60.87510	0.00344	0.00151	61.41531
Gasoline	Sport	130	0.73710	24.45300	0.63570	0.03276	0.03900	0.02535	61.34700	0.00347	0.00152	61.89140
Gasoline	Sport	131	0.74277	24.64110	0.64059	0.03301	0.03930	0.02555	61.81890	0.00350	0.00153	62.36749
Gasoline	Sport	132	0.74844	24.82920	0.64548	0.03326	0.03960	0.02574	62.29080	0.00352	0.00154	62.84358
Gasoline	Sport	133	0.75411	25.01730	0.65037	0.03352	0.03990	0.02594	62.76270	0.00355	0.00156	63.31966
Gasoline	Sport	134	0.75978	25.20540	0.65526	0.03377	0.04020	0.02613	63.23460	0.00358	0.00157	63.79575
Gasoline	Sport	135	0.76545	25.39350	0.66015	0.03402	0.04050	0.02633	63.70650	0.00360	0.00158	64.27184
Gasoline	Sport	136	0.77112	25.58160	0.66504	0.03427	0.04080	0.02652	64.17840	0.00363	0.00159	64.74793
Gasoline	Sport	137	0.77679	25.76970	0.66993	0.03452	0.04110	0.02672	64.65030	0.00366	0.00160	65.22401
Gasoline	Sport	138	0.78246	25.95780	0.67482	0.03478	0.04140	0.02691	65.12220	0.00368	0.00161	65.70010
Gasoline	Sport	139	0.78813	26.14590	0.67971	0.03503	0.04170	0.02711	65.59410	0.00371	0.00163	66.17619
Gasoline	Sport	140	0.79380	26.33400	0.68460	0.03528	0.04200	0.02730	66.06600	0.00374	0.00164	66.65228
Gasoline	Sport	141	0.79947	26.52210	0.68949	0.03553	0.04230	0.02750	66.53790	0.00376	0.00165	67.12837
Gasoline	Sport	142	0.80514	26.71020	0.69438	0.03578	0.04260	0.02769	67.00980	0.00379	0.00166	67.60445
Gasoline	Sport	143	0.81081	26.89830	0.69927	0.03604	0.04290	0.02789	67.48170	0.00382	0.00167	68.08054
Gasoline	Sport	144	0.81648	27.08640	0.70416	0.03629	0.04320	0.02808	67.95360	0.00384	0.00168	68.55663
Gasoline	Sport	145	0.82215	27.27450	0.70905	0.03654	0.04350	0.02828	68.42550	0.00387	0.00170	69.03272
Gasoline	Sport	146	0.82782	27.46260	0.71394	0.03679	0.04380	0.02847	68.89740	0.00390	0.00171	69.50880
Gasoline	Sport	147	0.83349	27.65070	0.71883	0.03704	0.04410	0.02867	69.36930	0.00392	0.00172	69.98489
Gasoline	Sport	148	0.83916	27.83880	0.72372	0.03730	0.04440	0.02886	69.84120	0.00395	0.00173	70.46098
Gasoline	Sport	149	0.84483	28.02690	0.72861	0.03755	0.04470	0.02906	70.31310	0.00398	0.00174	70.93707
Gasoline	Sport	150	0.85050	28.21500	0.73350	0.03780	0.04500	0.02925	70.78500	0.00401	0.00176	71.41316
Gasoline	Sport	151	0.85617	28.40310	0.73839	0.03805	0.04530	0.02945	71.25690	0.00403	0.00177	71.88924
Gasoline	Sport	152	0.86184	28.59120	0.74328	0.03830	0.04560	0.02964	71.72880	0.00406	0.00178	72.36533
Gasoline	Sport	153	0.86751	28.77930	0.74817	0.03856	0.04590	0.02984	72.20070	0.00409	0.00179	72.84142
Gasoline	Sport	154	0.87318	28.96740	0.75306	0.03881	0.04620	0.03003	72.67260	0.00411	0.00180	73.31751
Gasoline	Sport	155	0.87885	29.15550	0.75795	0.03906	0.04650	0.03023	73.14450	0.00414	0.00181	73.79359
Gasoline	Sport	156	0.88452	29.34360	0.76284	0.03931	0.04680	0.03042	73.61640	0.00417	0.00183	74.26968
Gasoline	Sport	157	0.89019	29.53170	0.76773	0.03956	0.04710	0.03062	74.08830	0.00419	0.00184	74.74577
Gasoline	Sport	158	0.89586	29.71980	0.77262	0.03982	0.04740	0.03081	74.56020	0.00422	0.00185	75.22186
Gasoline	Sport	159	0.90153	29.90790	0.77751	0.04007	0.04770	0.03101	75.03210	0.00425	0.00186	75.69794
Gasoline	Sport	160	0.90720	30.09600	0.78240	0.04032	0.04800	0.03120	75.50400	0.00427	0.00187	76.17403
Gasoline	Sport	161	0.91287	30.28410	0.78729	0.04057	0.04830	0.03140	75.97590	0.00430	0.00188	76.65012
Gasoline	Sport	162	0.91854	30.47220	0.79218	0.04082	0.04860	0.03159	76.44780	0.00433	0.00190	77.12621
Gasoline	Sport	163	0.92421	30.66030	0.79707	0.04108	0.04890	0.03179	76.91970	0.00435	0.00191	77.60230
Gasoline	Sport	164	0.92988	30.84840	0.80196	0.04133	0.04920	0.03198	77.39160	0.00438	0.00192	78.07838
Gasoline	Sport	165	0.93555	31.03650	0.80685	0.04158	0.04950	0.03218	77.86350	0.00441	0.00193	78.55447
Gasoline	Sport	166	0.94122	31.22460	0.81174	0.04183	0.04980	0.03237	78.33540	0.00443	0.00194	79.03056
Gasoline	Sport	167	0.94689	31.41270	0.81663	0.04208	0.05010	0.03257	78.80730	0.00446	0.00195	79.50665
Gasoline	Sport	168	0.95256	31.60080	0.82152	0.04234	0.05040	0.03276	79.27920	0.00449	0.00197	79.98273
Gasoline	Sport	169	0.95823	31.78890	0.82641	0.04259	0.05070	0.03296	79.75110	0.00451	0.00198	80.45882
Gasoline	Sport	170	0.96390	31.97700	0.83130	0.04284	0.05100	0.03315	80.22300	0.00454	0.00199	80.93491
Gasoline	Sport	171	0.96957	32.16510	0.83619	0.04309	0.05130	0.03335	80.69490	0.00457	0.00200	81.41100
Gasoline	Sport	172	0.97524	32.35320	0.84108	0.04334	0.05160	0.03354	81.16680	0.00459	0.00201	81.88708
Gasoline	Sport	173	0.98091	32.54130	0.84597	0.04360	0.05190	0.03374	81.63870	0.00462	0.00202	82.36317
Gasoline	Sport	174	0.98658	32.72940	0.85086	0.04385	0.05220	0.03393	82.11060	0.00465	0.00204	82.83926
Gasoline	Sport	175	0.99225	32.91750	0.85575	0.04410	0.05250	0.03413	82.58250	0.00467	0.00205	83.31535
Gasoline	Sport	176	0.99792	33.10560	0.86064	0.04435	0.05280	0.03432	83.05440	0.00470	0.00206	83.79144
Gasoline	Sport	177	1.00359	33.29370	0.86553	0.04460	0.05310	0.03452	83.52630	0.00473	0.00207	84.26752
Gasoline	Sport	178	1.00926	33.48180	0.87042	0.04486	0.05340	0.03471	83.99820	0.00475	0.00208	84.74361
Gasoline	Sport	179	1.01493	33.66990	0.87531	0.04511	0.05370	0.03491	84.47010	0.00478	0.00209	85.21970
Gasoline	Sport	180	1.02060	33.85800	0.88020	0.04536	0.05400	0.03510	84.94200	0.00481	0.00211	85.69579
Gasoline	Sport	181	1.02627	34.04610	0.88509	0.04561	0.05430	0.03530	85.41390	0.00483	0.00212	86.17187
Gasoline	Sport	182	1.03194	34.23420	0.88998	0.04586	0.05460	0.03549	85.88580	0.00486	0.00213	86.64796
Gasoline	Sport	183	1.03761	34.42230	0.89487	0.04612	0.05490	0.03569	86.35770	0.00489	0.00214	87.12405
Gasoline	Sport	184	1.04328	34.61040	0.89976	0.04637	0.05520	0.03588	86.82960	0.00491	0.00215	87.60014
Gasoline	Sport	185	1.04895	34.79850	0.90465	0.04662	0.05550	0.03608	87.30150	0.00494	0.00216	88.07622
Gasoline	Sport	186	1.05462	34.98660	0.90954	0.04687	0.05580	0.03627	87.77340	0.00497	0.00218	88.55231
Gasoline	Sport	187	1.06029	35.17470	0.91443	0.04712	0.05610	0.03647	88.24530	0.00499	0.00219	89.02840
Gasoline	Sport	188	1.06596	35.36280	0.91932	0.04738	0.05640	0.03666	88.71720	0.00502	0.00220	89.50449
Gasoline	Sport	189	1.07163	35.55090	0.92421	0.04763	0.05670	0.03686	89.18910	0.00505	0.00221	89.98058
Gasoline	Sport	190	1.07730	35.73900	0.92910	0.04788	0.05700	0.03705	89.66100	0.00507	0.00222	90.45666
Gasoline	Sport	191	1.08297	35.92710	0.93399	0.04813	0.05730	0.03725	90.13290	0.00510	0.00223	90.93275
Gasoline	Sport	192	1.08864	36.11520	0.93888	0.04838	0.05760	0.03744	90.60480	0.00513	0.00225	91.40884
Gasoline	Sport	193	1.09431	36.30330	0.94377	0.04864	0.05790	0.03764	91.07670	0.00515	0.00226	91.88493

Factors

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
Gasoline	Sport	194	1.09998	36.49140	0.94866	0.04889	0.05820	0.03783	91.54860	0.00518	0.00227	92.36101
Gasoline	Sport	195	1.10565	36.67950	0.95355	0.04914	0.05850	0.03803	92.02050	0.00521	0.00228	92.83710
Gasoline	Sport	196	1.11132	36.86760	0.95844	0.04939	0.05880	0.03822	92.49240	0.00523	0.00229	93.31319
Gasoline	Sport	197	1.11699	37.05570	0.96333	0.04964	0.05910	0.03842	92.96430	0.00526	0.00230	93.78928
Gasoline	Sport	198	1.12266	37.24380	0.96822	0.04990	0.05940	0.03861	93.43620	0.00529	0.00232	94.26536
Gasoline	Sport	199	1.12833	37.43190	0.97311	0.05015	0.05970	0.03881	93.90810	0.00531	0.00233	94.74145
Gasoline	**Sport**	**200**	**1.13400**	**37.62000**	**0.97800**	**0.05040**	**0.06000**	**0.03900**	**94.38000**	**0.00534**	**0.00234**	**95.21754**
Gasoline	Sport	210	1.19070	39.50100	1.02690	0.05292	0.06300	0.04095	99.09900	0.00561	0.00246	99.97842
Gasoline	Sport	220	1.24740	41.38200	1.07580	0.05544	0.06600	0.04290	103.81800	0.00587	0.00257	104.73929
Gasoline	Sport	230	1.30410	43.26300	1.12470	0.05796	0.06900	0.04485	108.53700	0.00614	0.00269	109.50017
Gasoline	Sport	240	1.36080	45.14400	1.17360	0.06048	0.07200	0.04680	113.25600	0.00641	0.00281	114.26105
Gasoline	Sport	250	1.41750	47.02500	1.22250	0.06300	0.07500	0.04875	117.97500	0.00668	0.00293	119.02193
Gasoline	Sport	260	1.47420	48.90600	1.27140	0.06552	0.07800	0.05070	122.69400	0.00694	0.00304	123.78280
Gasoline	Sport	270	1.53090	50.78700	1.32030	0.06804	0.08100	0.05265	127.41300	0.00721	0.00316	128.54368
Gasoline	Sport	280	1.58760	52.66800	1.36920	0.07056	0.08400	0.05460	132.13200	0.00748	0.00328	133.30456
Gasoline	Sport	290	1.64430	54.54900	1.41810	0.07308	0.08700	0.05655	136.85100	0.00774	0.00339	138.06543
Gasoline	Sport	300	1.70100	56.43000	1.46700	0.07560	0.09000	0.05850	141.57000	0.00801	0.00351	142.82631
Gasoline	Sport	310	1.75770	58.31100	1.51590	0.07812	0.09300	0.06045	146.28900	0.00828	0.00363	147.58719
Gasoline	Sport	320	1.81440	60.19200	1.56480	0.08064	0.09600	0.06240	151.00800	0.00854	0.00374	152.34806
Gasoline	Sport	330	1.87110	62.07300	1.61370	0.08316	0.09900	0.06435	155.72700	0.00881	0.00386	157.10894
Gasoline	Sport	340	1.92780	63.95400	1.66260	0.08568	0.10200	0.06630	160.44600	0.00908	0.00398	161.86982
Gasoline	Sport	350	1.98450	65.83500	1.71150	0.08820	0.10500	0.06825	165.16500	0.00935	0.00410	166.63070
Gasoline	Sport	360	2.04120	67.71600	1.76040	0.09072	0.10800	0.07020	169.88400	0.00961	0.00421	171.39157
Gasoline	Sport	370	2.09790	69.59700	1.80930	0.09324	0.11100	0.07215	174.60300	0.00988	0.00433	176.15245
Gasoline	Sport	380	2.15460	71.47800	1.85820	0.09576	0.11400	0.07410	179.32200	0.01015	0.00445	180.91333
Gasoline	Sport	390	2.21130	73.35900	1.90710	0.09828	0.11700	0.07605	184.04100	0.01041	0.00456	185.67420
Gasoline	Sport	400	2.26800	75.24000	1.95600	0.10080	0.12000	0.07800	188.76000	0.01068	0.00468	190.43508
Gasoline	Sport	410	2.32470	77.12100	2.00490	0.10332	0.12300	0.07995	193.47900	0.01095	0.00480	195.19596
Gasoline	Sport	420	2.38140	79.00200	2.05380	0.10584	0.12600	0.08190	198.19800	0.01121	0.00491	199.95683
Gasoline	Sport	430	2.43810	80.88300	2.10270	0.10836	0.12900	0.08385	202.91700	0.01148	0.00503	204.71771
Gasoline	Sport	440	2.49480	82.76400	2.15160	0.11088	0.13200	0.08580	207.63600	0.01175	0.00515	209.47859
Gasoline	Sport	450	2.55150	84.64500	2.20050	0.11340	0.13500	0.08775	212.35500	0.01202	0.00527	214.23947
Gasoline	Sport	460	2.60820	86.52600	2.24940	0.11592	0.13800	0.08970	217.07400	0.01228	0.00538	219.00034
Gasoline	Sport	470	2.66490	88.40700	2.29830	0.11844	0.14100	0.09165	221.79300	0.01255	0.00550	223.76122
Gasoline	Sport	480	2.72160	90.28800	2.34720	0.12096	0.14400	0.09360	226.51200	0.01282	0.00562	228.52210
Gasoline	Sport	490	2.77830	92.16900	2.39610	0.12348	0.14700	0.09555	231.23100	0.01308	0.00573	233.28297
Gasoline	Sport	500	2.83500	94.05000	2.44500	0.12600	0.15000	0.09750	235.95000	0.01335	0.00585	238.04385
Jet A	**Turbine**	**200**	**0.00065**	**0.00521**	**1.38960**	**0.00245**	**0.01895**	**0.01232**	**257.90400**	**0.00713**	**0.00826**	**260.61491**
Jet A	Turbine	210	0.00068	0.00547	1.45908	0.00258	0.01990	0.01293	270.79920	0.00748	0.00868	273.64565
Jet A	Turbine	220	0.00071	0.00573	1.52856	0.00270	0.02084	0.01355	283.69440	0.00784	0.00909	286.67640
Jet A	Turbine	230	0.00074	0.00599	1.59804	0.00282	0.02179	0.01416	296.58960	0.00820	0.00950	299.70714
Jet A	Turbine	240	0.00078	0.00625	1.66752	0.00295	0.02274	0.01478	309.48480	0.00855	0.00991	312.73789
Jet A	Turbine	250	0.00081	0.00651	1.73700	0.00307	0.02369	0.01540	322.38000	0.00891	0.01033	325.76864
Jet A	Turbine	260	0.00084	0.00677	1.80648	0.00319	0.02463	0.01601	335.27520	0.00927	0.01074	338.79938
Jet A	Turbine	270	0.00087	0.00703	1.87596	0.00331	0.02558	0.01663	348.17040	0.00962	0.01115	351.83013
Jet A	Turbine	280	0.00091	0.00730	1.94544	0.00344	0.02653	0.01724	361.06560	0.00998	0.01157	364.86087
Jet A	Turbine	290	0.00094	0.00756	2.01492	0.00356	0.02748	0.01786	373.96080	0.01034	0.01198	377.89162
Jet A	Turbine	300	0.00097	0.00782	2.08440	0.00368	0.02842	0.01848	386.85600	0.01069	0.01239	390.92236
Jet A	Turbine	310	0.00100	0.00808	2.15388	0.00380	0.02937	0.01909	399.75120	0.01105	0.01281	403.95311
Jet A	Turbine	320	0.00104	0.00834	2.22336	0.00393	0.03032	0.01971	412.64640	0.01140	0.01322	416.98385
Jet A	Turbine	330	0.00107	0.00860	2.29284	0.00405	0.03127	0.02032	425.54160	0.01176	0.01363	430.01460
Jet A	Turbine	340	0.00110	0.00886	2.36232	0.00417	0.03221	0.02094	438.43680	0.01212	0.01405	443.04534
Jet A	Turbine	350	0.00113	0.00912	2.43180	0.00430	0.03316	0.02155	451.33200	0.01247	0.01446	456.07609
Jet A	Turbine	360	0.00117	0.00938	2.50128	0.00442	0.03411	0.02217	464.22720	0.01283	0.01487	469.10683
Jet A	Turbine	370	0.00120	0.00964	2.57076	0.00454	0.03506	0.02279	477.12240	0.01319	0.01528	482.13758
Jet A	Turbine	380	0.00123	0.00990	2.64024	0.00466	0.03600	0.02340	490.01760	0.01354	0.01570	495.16833
Jet A	Turbine	390	0.00126	0.01016	2.70972	0.00479	0.03695	0.02402	502.91280	0.01390	0.01611	508.19907
Jet A	Turbine	400	0.00129	0.01042	2.77920	0.00491	0.03790	0.02463	515.80800	0.01426	0.01652	521.22982
Jet A	Turbine	410	0.00133	0.01068	2.84868	0.00503	0.03885	0.02525	528.70320	0.01461	0.01694	534.26056
Jet A	Turbine	420	0.00136	0.01094	2.91816	0.00515	0.03979	0.02587	541.59840	0.01497	0.01735	547.29131
Jet A	Turbine	430	0.00139	0.01120	2.98764	0.00528	0.04074	0.02648	554.49360	0.01533	0.01776	560.32205
Jet A	Turbine	440	0.00142	0.01146	3.05712	0.00540	0.04169	0.02710	567.38880	0.01568	0.01818	573.35280
Jet A	Turbine	450	0.00146	0.01172	3.12660	0.00552	0.04264	0.02771	580.28400	0.01604	0.01859	586.38354
Jet A	Turbine	460	0.00149	0.01199	3.19608	0.00565	0.04358	0.02833	593.17920	0.01639	0.01900	599.41429
Jet A	Turbine	470	0.00152	0.01225	3.26556	0.00577	0.04453	0.02894	606.07440	0.01675	0.01942	612.44503
Jet A	Turbine	480	0.00155	0.01251	3.33504	0.00589	0.04548	0.02956	618.96960	0.01711	0.01983	625.47578
Jet A	Turbine	490	0.00159	0.01277	3.40452	0.00601	0.04643	0.03018	631.86480	0.01746	0.02024	638.50652
Jet A	Turbine	500	0.00162	0.01303	3.47400	0.00614	0.04737	0.03079	644.76000	0.01782	0.02066	651.53727
Jet A	Turbine	510	0.00165	0.01329	3.54348	0.00626	0.04832	0.03141	657.65520	0.01818	0.02107	664.56802
Jet A	Turbine	520	0.00168	0.01355	3.61296	0.00638	0.04927	0.03202	670.55040	0.01853	0.02148	677.59876
Jet A	Turbine	530	0.00172	0.01381	3.68244	0.00650	0.05022	0.03264	683.44560	0.01889	0.02189	690.62951
Jet A	Turbine	540	0.00175	0.01407	3.75192	0.00663	0.05116	0.03326	696.34080	0.01925	0.02231	703.66025
Jet A	Turbine	550	0.00178	0.01433	3.82140	0.00675	0.05211	0.03387	709.23600	0.01960	0.02272	716.69100
Jet A	Turbine	560	0.00181	0.01459	3.89088	0.00687	0.05306	0.03449	722.13120	0.01996	0.02313	729.72174
Jet A	Turbine	570	0.00185	0.01485	3.96036	0.00700	0.05400	0.03510	735.02640	0.02031	0.02355	742.75249
Jet A	Turbine	580	0.00188	0.01511	4.02984	0.00712	0.05495	0.03572	747.92160	0.02067	0.02396	755.78323
Jet A	Turbine	590	0.00191	0.01537	4.09932	0.00724	0.05590	0.03633	760.81680	0.02103	0.02437	768.81398
Jet A	Turbine	600	0.00194	0.01563	4.16880	0.00736	0.05685	0.03695	773.71200	0.02138	0.02479	781.84472

Factors

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
Jet A	Turbine	610	0.00197	0.01589	4.23828	0.00749	0.05779	0.03757	786.60720	0.02174	0.02520	794.87547
Jet A	Turbine	620	0.00201	0.01615	4.30776	0.00761	0.05874	0.03818	799.50240	0.02210	0.02561	807.90621
Jet A	Turbine	630	0.00204	0.01641	4.37724	0.00773	0.05969	0.03880	812.39760	0.02245	0.02603	820.93696
Jet A	Turbine	640	0.00207	0.01668	4.44672	0.00785	0.06064	0.03941	825.29280	0.02281	0.02644	833.96771
Jet A	Turbine	650	0.00210	0.01694	4.51620	0.00798	0.06158	0.04003	838.18800	0.02317	0.02685	846.99845
Jet A	Turbine	660	0.00214	0.01720	4.58568	0.00810	0.06253	0.04065	851.08320	0.02352	0.02726	860.02920
Jet A	Turbine	670	0.00217	0.01746	4.65516	0.00822	0.06348	0.04126	863.97840	0.02388	0.02768	873.05994
Jet A	Turbine	680	0.00220	0.01772	4.72464	0.00835	0.06443	0.04188	876.87360	0.02424	0.02809	886.09069
Jet A	Turbine	690	0.00223	0.01798	4.79412	0.00847	0.06537	0.04249	889.76880	0.02459	0.02850	899.12143
Jet A	Turbine	700	0.00227	0.01824	4.86360	0.00859	0.06632	0.04311	902.66400	0.02495	0.02892	912.15218
Jet A	Turbine	710	0.00230	0.01850	4.93308	0.00871	0.06727	0.04373	915.55920	0.02530	0.02933	925.18292
Jet A	Turbine	720	0.00233	0.01876	5.00256	0.00884	0.06822	0.04434	928.45440	0.02566	0.02974	938.21367
Jet A	Turbine	730	0.00236	0.01902	5.07204	0.00896	0.06916	0.04496	941.34960	0.02602	0.03016	951.24441
Jet A	Turbine	740	0.00240	0.01928	5.14152	0.00908	0.07011	0.04557	954.24480	0.02637	0.03057	964.27516
Jet A	Turbine	750	0.00243	0.01954	5.21100	0.00920	0.07106	0.04619	967.14000	0.02673	0.03098	977.30591
Jet A	Turbine	760	0.00246	0.01980	5.28048	0.00933	0.07201	0.04680	980.03520	0.02709	0.03140	990.33665
Jet A	Turbine	770	0.00249	0.02006	5.34996	0.00945	0.07295	0.04742	992.93040	0.02744	0.03181	1003.36740
Jet A	Turbine	780	0.00252	0.02032	5.41944	0.00957	0.07390	0.04804	1005.82560	0.02780	0.03222	1016.39814
Jet A	Turbine	790	0.00256	0.02058	5.48892	0.00970	0.07485	0.04865	1018.72080	0.02816	0.03263	1029.42889
Jet A	Turbine	800	0.00259	0.02084	5.55840	0.00982	0.07580	0.04927	1031.61600	0.02851	0.03305	1042.45963
Jet A	Turbine	810	0.00262	0.02110	5.62788	0.00994	0.07674	0.04988	1044.51120	0.02887	0.03346	1055.49038
Jet A	Turbine	820	0.00265	0.02137	5.69736	0.01006	0.07769	0.05050	1057.40640	0.02922	0.03387	1068.52112
Jet A	Turbine	830	0.00269	0.02163	5.76684	0.01019	0.07864	0.05112	1070.30160	0.02958	0.03429	1081.55187
Jet A	Turbine	840	0.00272	0.02189	5.83632	0.01031	0.07959	0.05173	1083.19680	0.02994	0.03470	1094.58261
Jet A	Turbine	850	0.00275	0.02215	5.90580	0.01043	0.08053	0.05235	1096.09200	0.03029	0.03511	1107.61336
Jet A	Turbine	860	0.00278	0.02241	5.97528	0.01055	0.08148	0.05296	1108.98720	0.03065	0.03553	1120.64410
Jet A	Turbine	870	0.00282	0.02267	6.04476	0.01068	0.08243	0.05358	1121.88240	0.03101	0.03594	1133.67485
Jet A	Turbine	880	0.00285	0.02293	6.11424	0.01080	0.08338	0.05419	1134.77760	0.03136	0.03635	1146.70560
Jet A	Turbine	890	0.00288	0.02319	6.18372	0.01092	0.08432	0.05481	1147.67280	0.03172	0.03677	1159.73634
Jet A	Turbine	900	0.00291	0.02345	6.25320	0.01105	0.08527	0.05543	1160.56800	0.03208	0.03718	1172.76709
Jet A	Turbine	910	0.00295	0.02371	6.32268	0.01117	0.08622	0.05604	1173.46320	0.03243	0.03759	1185.79783
Jet A	Turbine	920	0.00298	0.02397	6.39216	0.01129	0.08717	0.05666	1186.35840	0.03279	0.03801	1198.82858
Jet A	Turbine	930	0.00301	0.02423	6.46164	0.01141	0.08811	0.05727	1199.25360	0.03315	0.03842	1211.85932
Jet A	Turbine	940	0.00304	0.02449	6.53112	0.01154	0.08906	0.05789	1212.14880	0.03350	0.03883	1224.89007
Jet A	Turbine	950	0.00308	0.02475	6.60060	0.01166	0.09001	0.05851	1225.04400	0.03386	0.03924	1237.92081
Jet A	Turbine	960	0.00311	0.02501	6.67008	0.01178	0.09096	0.05912	1237.93920	0.03421	0.03966	1250.95156
Jet A	Turbine	970	0.00314	0.02527	6.73956	0.01190	0.09190	0.05974	1250.83440	0.03457	0.04007	1263.98230
Jet A	Turbine	980	0.00317	0.02553	6.80904	0.01203	0.09285	0.06035	1263.72960	0.03493	0.04048	1277.01305
Jet A	Turbine	990	0.00320	0.02579	6.87852	0.01215	0.09380	0.06097	1276.62480	0.03528	0.04090	1290.04379
Jet A	Turbine	1000	0.00324	0.02606	6.94800	0.01227	0.09475	0.06158	1289.52000	0.03564	0.04131	1303.07454
Gasoline	**Utility**	**1.0**	**0.00657**	**0.50143**	**0.00560**	**0.00043**	**0.00049**	**0.00032**	**0.94380**	**0.00005**	**0.00002**	**0.95218**
Gasoline	Utility	1.1	0.00723	0.55157	0.00616	0.00047	0.00053	0.00035	1.03818	0.00006	0.00003	1.04739
Gasoline	Utility	1.2	0.00788	0.60171	0.00672	0.00052	0.00058	0.00038	1.13256	0.00006	0.00003	1.14261
Gasoline	Utility	1.3	0.00854	0.65185	0.00728	0.00056	0.00063	0.00041	1.22694	0.00007	0.00003	1.23783
Gasoline	Utility	1.4	0.00920	0.70200	0.00783	0.00060	0.00068	0.00044	1.32132	0.00007	0.00003	1.33305
Gasoline	Utility	1.5	0.00985	0.75214	0.00839	0.00064	0.00073	0.00047	1.41570	0.00008	0.00004	1.42826
Gasoline	Utility	1.6	0.01051	0.80228	0.00895	0.00069	0.00078	0.00050	1.51008	0.00009	0.00004	1.52348
Gasoline	Utility	1.7	0.01117	0.85243	0.00951	0.00073	0.00082	0.00054	1.60446	0.00009	0.00004	1.61870
Gasoline	Utility	1.8	0.01183	0.90257	0.01007	0.00077	0.00087	0.00057	1.69884	0.00010	0.00004	1.71392
Gasoline	Utility	1.9	0.01248	0.95271	0.01063	0.00082	0.00092	0.00060	1.79322	0.00010	0.00004	1.80913
Gasoline	Utility	2.0	0.01314	1.00285	0.01119	0.00086	0.00097	0.00063	1.88760	0.00011	0.00005	1.90435
Gasoline	Utility	2.1	0.01380	1.05300	0.01175	0.00090	0.00102	0.00066	1.98198	0.00011	0.00005	1.99957
Gasoline	Utility	2.2	0.01445	1.10314	0.01231	0.00095	0.00107	0.00069	2.07636	0.00012	0.00005	2.09479
Gasoline	Utility	2.3	0.01511	1.15328	0.01287	0.00099	0.00112	0.00073	2.17074	0.00012	0.00005	2.19000
Gasoline	Utility	2.4	0.01577	1.20342	0.01343	0.00103	0.00116	0.00076	2.26512	0.00013	0.00006	2.28522
Gasoline	Utility	2.5	0.01642	1.25357	0.01399	0.00107	0.00121	0.00079	2.35950	0.00013	0.00006	2.38044
Gasoline	Utility	2.6	0.01708	1.30371	0.01455	0.00112	0.00126	0.00082	2.45388	0.00014	0.00006	2.47566
Gasoline	Utility	2.7	0.01774	1.35385	0.01511	0.00116	0.00131	0.00085	2.54826	0.00014	0.00006	2.57087
Gasoline	Utility	2.8	0.01839	1.40400	0.01567	0.00120	0.00136	0.00088	2.64264	0.00015	0.00007	2.66609
Gasoline	Utility	2.9	0.01905	1.45414	0.01623	0.00125	0.00141	0.00091	2.73702	0.00015	0.00007	2.76131
Gasoline	**Utility**	**3.0**	**0.01505**	**1.50428**	**0.01282**	**0.00129**	**0.00146**	**0.00095**	**2.59545**	**0.00015**	**0.00006**	**2.61848**
Gasoline	Utility	3.1	0.01555	1.55442	0.01325	0.00133	0.00150	0.00098	2.68197	0.00015	0.00007	2.70577
Gasoline	Utility	3.2	0.01605	1.60457	0.01367	0.00138	0.00155	0.00101	2.76848	0.00016	0.00007	2.79305
Gasoline	Utility	3.3	0.01655	1.65471	0.01410	0.00142	0.00160	0.00104	2.85500	0.00016	0.00007	2.88033
Gasoline	Utility	3.4	0.01705	1.70485	0.01453	0.00146	0.00165	0.00107	2.94151	0.00017	0.00007	2.96761
Gasoline	Utility	3.5	0.01756	1.75499	0.01495	0.00150	0.00170	0.00110	3.02803	0.00017	0.00008	3.05490
Gasoline	Utility	3.6	0.01806	1.80514	0.01538	0.00155	0.00175	0.00113	3.11454	0.00018	0.00008	3.14218
Gasoline	Utility	3.7	0.01856	1.85528	0.01581	0.00159	0.00179	0.00117	3.20106	0.00018	0.00008	3.22946
Gasoline	Utility	3.8	0.01906	1.90542	0.01624	0.00163	0.00184	0.00120	3.28757	0.00019	0.00008	3.31674
Gasoline	Utility	3.9	0.01956	1.95556	0.01666	0.00168	0.00189	0.00123	3.37409	0.00019	0.00008	3.40403
Gasoline	Utility	4.0	0.02006	2.00571	0.01709	0.00172	0.00194	0.00126	3.46060	0.00020	0.00009	3.49131
Gasoline	Utility	4.1	0.02057	2.05585	0.01752	0.00176	0.00199	0.00129	3.54712	0.00020	0.00009	3.57859
Gasoline	Utility	4.2	0.02107	2.10599	0.01795	0.00181	0.00204	0.00132	3.63363	0.00021	0.00009	3.66588
Gasoline	Utility	4.3	0.02157	2.15614	0.01837	0.00185	0.00209	0.00136	3.72015	0.00021	0.00009	3.75316
Gasoline	Utility	4.4	0.02207	2.20628	0.01880	0.00189	0.00213	0.00139	3.80666	0.00022	0.00009	3.84044
Gasoline	Utility	4.5	0.02257	2.25642	0.01923	0.00193	0.00218	0.00142	3.89318	0.00022	0.00010	3.92772
Gasoline	Utility	4.6	0.02307	2.30656	0.01965	0.00198	0.00223	0.00145	3.97969	0.00023	0.00010	4.01501
Gasoline	Utility	4.7	0.02357	2.35671	0.02008	0.00202	0.00228	0.00148	4.06621	0.00023	0.00010	4.10229

Factors

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
Gasoline	Utility	4.8	0.02408	2.40685	0.02051	0.00206	0.00233	0.00151	4.15272	0.00023	0.00010	4.18957
Gasoline	Utility	4.9	0.02458	2.45699	0.02094	0.00211	0.00238	0.00154	4.23924	0.00024	0.00011	4.27685
Gasoline	Utility	5.0	0.02508	2.50713	0.02136	0.00215	0.00243	0.00158	4.32575	0.00024	0.00011	4.36414
Gasoline	Utility	5.1	0.02558	2.55728	0.02179	0.00219	0.00247	0.00161	4.41227	0.00025	0.00011	4.45142
Gasoline	Utility	5.2	0.02608	2.60742	0.02222	0.00224	0.00252	0.00164	4.49878	0.00025	0.00011	4.53870
Gasoline	Utility	5.3	0.02658	2.65756	0.02265	0.00228	0.00257	0.00167	4.58530	0.00026	0.00011	4.62599
Gasoline	Utility	5.4	0.02709	2.70771	0.02307	0.00232	0.00262	0.00170	4.67181	0.00026	0.00012	4.71327
Gasoline	Utility	5.5	0.02759	2.75785	0.02350	0.00236	0.00267	0.00173	4.75833	0.00027	0.00012	4.80055
Gasoline	Utility	5.6	0.02809	2.80799	0.02393	0.00241	0.00272	0.00177	4.84484	0.00027	0.00012	4.88783
Gasoline	Utility	5.7	0.02859	2.85813	0.02436	0.00245	0.00276	0.00180	4.93136	0.00028	0.00012	4.97512
Gasoline	Utility	5.8	0.02909	2.90828	0.02478	0.00249	0.00281	0.00183	5.01787	0.00028	0.00012	5.06240
Gasoline	Utility	5.9	0.02959	2.95842	0.02521	0.00254	0.00286	0.00186	5.10439	0.00029	0.00013	5.14968
Gasoline	Utility	6.0	0.03010	3.00856	0.02564	0.00258	0.00291	0.00189	5.19090	0.00029	0.00013	5.23696
Gasoline	Utility	6.1	0.03060	3.05870	0.02606	0.00262	0.00296	0.00192	5.27742	0.00030	0.00013	5.32425
Gasoline	Utility	6.2	0.03110	3.10885	0.02649	0.00267	0.00301	0.00195	5.36393	0.00030	0.00013	5.41153
Gasoline	Utility	6.3	0.03160	3.15899	0.02692	0.00271	0.00306	0.00199	5.45045	0.00031	0.00014	5.49881
Gasoline	Utility	6.4	0.03210	3.20913	0.02735	0.00275	0.00310	0.00202	5.53696	0.00031	0.00014	5.58610
Gasoline	Utility	6.5	0.03260	3.25927	0.02777	0.00279	0.00315	0.00205	5.62348	0.00032	0.00014	5.67338
Gasoline	Utility	6.6	0.03311	3.30942	0.02820	0.00284	0.00320	0.00208	5.70999	0.00032	0.00014	5.76066
Gasoline	Utility	6.7	0.03361	3.35956	0.02863	0.00288	0.00325	0.00211	5.79651	0.00033	0.00014	5.84794
Gasoline	Utility	6.8	0.03411	3.40970	0.02906	0.00292	0.00330	0.00214	5.88302	0.00033	0.00015	5.93523
Gasoline	Utility	6.9	0.03461	3.45985	0.02948	0.00297	0.00335	0.00218	5.96954	0.00034	0.00015	6.02251
Gasoline	Utility	7.0	0.03511	3.50999	0.02991	0.00301	0.00340	0.00221	6.05605	0.00034	0.00015	6.10979
Gasoline	Utility	7.1	0.03561	3.56013	0.03034	0.00305	0.00344	0.00224	6.14257	0.00035	0.00015	6.19707
Gasoline	Utility	7.2	0.03611	3.61027	0.03076	0.00310	0.00349	0.00227	6.22908	0.00035	0.00015	6.28436
Gasoline	Utility	7.3	0.03662	3.66042	0.03119	0.00314	0.00354	0.00230	6.31560	0.00036	0.00016	6.37164
Gasoline	Utility	7.4	0.03712	3.71056	0.03162	0.00318	0.00359	0.00233	6.40211	0.00036	0.00016	6.45892
Gasoline	Utility	7.5	0.03762	3.76070	0.03205	0.00322	0.00364	0.00236	6.48863	0.00037	0.00016	6.54621
Gasoline	Utility	7.6	0.03812	3.81084	0.03247	0.00327	0.00369	0.00240	6.57514	0.00037	0.00016	6.63349
Gasoline	Utility	7.7	0.03862	3.86099	0.03290	0.00331	0.00373	0.00243	6.66166	0.00038	0.00017	6.72077
Gasoline	Utility	7.8	0.03912	3.91113	0.03333	0.00335	0.00378	0.00246	6.74817	0.00038	0.00017	6.80805
Gasoline	Utility	7.9	0.03963	3.96127	0.03376	0.00340	0.00383	0.00249	6.83469	0.00039	0.00017	6.89534
Gasoline	Utility	8.0	0.04013	4.01141	0.03418	0.00344	0.00388	0.00252	6.92120	0.00039	0.00017	6.98262
Gasoline	Utility	8.1	0.04063	4.06156	0.03461	0.00348	0.00393	0.00255	7.00772	0.00040	0.00017	7.06990
Gasoline	Utility	8.2	0.04113	4.11170	0.03504	0.00353	0.00398	0.00259	7.09423	0.00040	0.00018	7.15719
Gasoline	Utility	8.3	0.04163	4.16184	0.03546	0.00357	0.00403	0.00262	7.18075	0.00041	0.00018	7.24447
Gasoline	Utility	8.4	0.04213	4.21199	0.03589	0.00361	0.00407	0.00265	7.26726	0.00041	0.00018	7.33175
Gasoline	Utility	8.5	0.04264	4.26213	0.03632	0.00365	0.00412	0.00268	7.35378	0.00042	0.00018	7.41903
Gasoline	Utility	8.6	0.04314	4.31227	0.03675	0.00370	0.00417	0.00271	7.44029	0.00042	0.00018	7.50632
Gasoline	Utility	8.7	0.04364	4.36241	0.03717	0.00374	0.00422	0.00274	7.52681	0.00043	0.00019	7.59360
Gasoline	Utility	8.8	0.04414	4.41256	0.03760	0.00378	0.00427	0.00277	7.61332	0.00043	0.00019	7.68088
Gasoline	Utility	8.9	0.04464	4.46270	0.03803	0.00383	0.00432	0.00281	7.69984	0.00044	0.00019	7.76816
Gasoline	Utility	9.0	0.04514	4.51284	0.03846	0.00387	0.00437	0.00284	7.78635	0.00044	0.00019	7.85545
Gasoline	Utility	9.1	0.04564	4.56298	0.03888	0.00391	0.00441	0.00287	7.87287	0.00045	0.00020	7.94273
Gasoline	Utility	9.2	0.04615	4.61313	0.03931	0.00396	0.00446	0.00290	7.95938	0.00045	0.00020	8.03001
Gasoline	Utility	9.3	0.04665	4.66327	0.03974	0.00400	0.00451	0.00293	8.04590	0.00046	0.00020	8.11730
Gasoline	Utility	9.4	0.04715	4.71341	0.04016	0.00404	0.00456	0.00296	8.13241	0.00046	0.00020	8.20458
Gasoline	Utility	9.5	0.04765	4.76356	0.04059	0.00408	0.00461	0.00299	8.21893	0.00047	0.00020	8.29186
Gasoline	Utility	9.6	0.04815	4.81370	0.04102	0.00413	0.00466	0.00303	8.30544	0.00047	0.00021	8.37914
Gasoline	Utility	9.7	0.04865	4.86384	0.04145	0.00417	0.00470	0.00306	8.39196	0.00047	0.00021	8.46643
Gasoline	Utility	9.8	0.04916	4.91398	0.04187	0.00421	0.00475	0.00309	8.47847	0.00048	0.00021	8.55371
Gasoline	Utility	9.9	0.04966	4.96413	0.04230	0.00426	0.00480	0.00312	8.56499	0.00048	0.00021	8.64099
Gasoline	Utility	10	0.09450	3.13500	0.08150	0.00420	0.00500	0.00325	7.86500	0.00045	0.00020	7.93480
Gasoline	Utility	11	0.10395	3.44850	0.08965	0.00462	0.00550	0.00358	8.65150	0.00049	0.00021	8.72827
Gasoline	Utility	12	0.11340	3.76200	0.09780	0.00504	0.00600	0.00390	9.43800	0.00053	0.00023	9.52175
Gasoline	Utility	13	0.12285	4.07550	0.10595	0.00546	0.00650	0.00423	10.22450	0.00058	0.00025	10.31523
Gasoline	Utility	14	0.13230	4.38900	0.11410	0.00588	0.00700	0.00455	11.01100	0.00062	0.00027	11.10871
Gasoline	Utility	15	0.14175	4.70250	0.12225	0.00630	0.00750	0.00488	11.79750	0.00067	0.00029	11.90219
Gasoline	Utility	16	0.15120	5.01600	0.13040	0.00672	0.00800	0.00520	12.58400	0.00071	0.00031	12.69567
Gasoline	Utility	17	0.16065	5.32950	0.13855	0.00714	0.00850	0.00553	13.37050	0.00076	0.00033	13.48915
Gasoline	Utility	18	0.17010	5.64300	0.14670	0.00756	0.00900	0.00585	14.15700	0.00080	0.00035	14.28263
Gasoline	Utility	19	0.17955	5.95650	0.15485	0.00798	0.00950	0.00618	14.94350	0.00085	0.00037	15.07611
Gasoline	Utility	20	0.18900	6.27000	0.16300	0.00840	0.01000	0.00650	15.73000	0.00089	0.00039	15.86959
Gasoline	Utility	21	0.19845	6.58350	0.17115	0.00882	0.01050	0.00683	16.51650	0.00093	0.00041	16.66307
Gasoline	Utility	22	0.20790	6.89700	0.17930	0.00924	0.01100	0.00715	17.30300	0.00098	0.00043	17.45655
Gasoline	Utility	23	0.21735	7.21050	0.18745	0.00966	0.01150	0.00748	18.08950	0.00102	0.00045	18.25003
Gasoline	Utility	24	0.22680	7.52400	0.19560	0.01008	0.01200	0.00780	18.87600	0.00107	0.00047	19.04351
Gasoline	Utility	25	0.23625	7.83750	0.20375	0.01050	0.01250	0.00813	19.66250	0.00111	0.00049	19.83699
Gasoline	Utility	26	0.24570	8.15100	0.21190	0.01092	0.01300	0.00845	20.44900	0.00116	0.00051	20.63047
Gasoline	Utility	27	0.25515	8.46450	0.22005	0.01134	0.01350	0.00878	21.23550	0.00120	0.00053	21.42395
Gasoline	Utility	28	0.26460	8.77800	0.22820	0.01176	0.01400	0.00910	22.02200	0.00125	0.00055	22.21743
Gasoline	Utility	29	0.27405	9.09150	0.23635	0.01218	0.01450	0.00943	22.80850	0.00129	0.00057	23.01091
Gasoline	Utility	30	0.28350	9.40500	0.24450	0.01260	0.01500	0.00975	23.59500	0.00134	0.00059	23.80439
Gasoline	Utility	31	0.29295	9.71850	0.25265	0.01302	0.01550	0.01008	24.38150	0.00138	0.00060	24.59786
Gasoline	Utility	32	0.30240	10.03200	0.26080	0.01344	0.01600	0.01040	25.16800	0.00142	0.00062	25.39134
Gasoline	Utility	33	0.31185	10.34550	0.26895	0.01386	0.01650	0.01073	25.95450	0.00147	0.00064	26.18482
Gasoline	Utility	34	0.32130	10.65900	0.27710	0.01428	0.01700	0.01105	26.74100	0.00151	0.00066	26.97830
Gasoline	Utility	35	0.33075	10.97250	0.28525	0.01470	0.01750	0.01138	27.52750	0.00156	0.00068	27.77178

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
Gasoline	Utility	36	0.34020	11.28600	0.29340	0.01512	0.01800	0.01170	28.31400	0.00160	0.00070	28.56526
Gasoline	Utility	37	0.34965	11.59950	0.30155	0.01554	0.01850	0.01203	29.10050	0.00165	0.00072	29.35874
Gasoline	Utility	38	0.35910	11.91300	0.30970	0.01596	0.01900	0.01235	29.88700	0.00169	0.00074	30.15222
Gasoline	Utility	39	0.36855	12.22650	0.31785	0.01638	0.01950	0.01268	30.67350	0.00174	0.00076	30.94570
Gasoline	Utility	40	0.37800	12.54000	0.32600	0.01680	0.02000	0.01300	31.46000	0.00178	0.00078	31.73918
Gasoline	Utility	41	0.38745	12.85350	0.33415	0.01722	0.02050	0.01333	32.24650	0.00182	0.00080	32.53266
Gasoline	Utility	42	0.39690	13.16700	0.34230	0.01764	0.02100	0.01365	33.03300	0.00187	0.00082	33.32614
Gasoline	Utility	43	0.40635	13.48050	0.35045	0.01806	0.02150	0.01398	33.81950	0.00191	0.00084	34.11962
Gasoline	Utility	44	0.41580	13.79400	0.35860	0.01848	0.02200	0.01430	34.60600	0.00196	0.00086	34.91310
Gasoline	Utility	45	0.42525	14.10750	0.36675	0.01890	0.02250	0.01463	35.39250	0.00200	0.00088	35.70658
Gasoline	Utility	46	0.43470	14.42100	0.37490	0.01932	0.02300	0.01495	36.17900	0.00205	0.00090	36.50006
Gasoline	Utility	47	0.44415	14.73450	0.38305	0.01974	0.02350	0.01528	36.96550	0.00209	0.00092	37.29354
Gasoline	Utility	48	0.45360	15.04800	0.39120	0.02016	0.02400	0.01560	37.75200	0.00214	0.00094	38.08702
Gasoline	Utility	49	0.46305	15.36150	0.39935	0.02058	0.02450	0.01593	38.53850	0.00218	0.00096	38.88050
Gasoline	Utility	50	0.47250	15.67500	0.40750	0.02100	0.02500	0.01625	39.32500	0.00223	0.00098	39.67398
Gasoline	Utility	51	0.48195	15.98850	0.41565	0.02142	0.02550	0.01658	40.11150	0.00227	0.00099	40.46745
Gasoline	Utility	52	0.49140	16.30200	0.42380	0.02184	0.02600	0.01690	40.89800	0.00231	0.00101	41.26093
Gasoline	Utility	53	0.50085	16.61550	0.43195	0.02226	0.02650	0.01723	41.68450	0.00236	0.00103	42.05441
Gasoline	Utility	54	0.51030	16.92900	0.44010	0.02268	0.02700	0.01755	42.47100	0.00240	0.00105	42.84789
Gasoline	Utility	55	0.51975	17.24250	0.44825	0.02310	0.02750	0.01788	43.25750	0.00245	0.00107	43.64137
Gasoline	Utility	56	0.52920	17.55600	0.45640	0.02352	0.02800	0.01820	44.04400	0.00249	0.00109	44.43485
Gasoline	Utility	57	0.53865	17.86950	0.46455	0.02394	0.02850	0.01853	44.83050	0.00254	0.00111	45.22833
Gasoline	Utility	58	0.54810	18.18300	0.47270	0.02436	0.02900	0.01885	45.61700	0.00258	0.00113	46.02181
Gasoline	Utility	59	0.55755	18.49650	0.48085	0.02478	0.02950	0.01918	46.40350	0.00263	0.00115	46.81529
Gasoline	Utility	60	0.56700	18.81000	0.48900	0.02520	0.03000	0.01950	47.19000	0.00267	0.00117	47.60877
Gasoline	Utility	61	0.57645	19.12350	0.49715	0.02562	0.03050	0.01983	47.97650	0.00271	0.00119	48.40225
Gasoline	Utility	62	0.58590	19.43700	0.50530	0.02604	0.03100	0.02015	48.76300	0.00276	0.00121	49.19573
Gasoline	Utility	63	0.59535	19.75050	0.51345	0.02646	0.03150	0.02048	49.54950	0.00280	0.00123	49.98921
Gasoline	Utility	64	0.60480	20.06400	0.52160	0.02688	0.03200	0.02080	50.33600	0.00285	0.00125	50.78269
Gasoline	Utility	65	0.61425	20.37750	0.52975	0.02730	0.03250	0.02113	51.12250	0.00289	0.00127	51.57617
Gasoline	Utility	66	0.62370	20.69100	0.53790	0.02772	0.03300	0.02145	51.90900	0.00294	0.00129	52.36965
Gasoline	Utility	67	0.63315	21.00450	0.54605	0.02814	0.03350	0.02178	52.69550	0.00298	0.00131	53.16313
Gasoline	Utility	68	0.64260	21.31800	0.55420	0.02856	0.03400	0.02210	53.48200	0.00303	0.00133	53.95661
Gasoline	Utility	69	0.65205	21.63150	0.56235	0.02898	0.03450	0.02243	54.26850	0.00307	0.00135	54.75009
Gasoline	Utility	70	0.66150	21.94500	0.57050	0.02940	0.03500	0.02275	55.05500	0.00312	0.00137	55.54357
Gasoline	Utility	71	0.67095	22.25850	0.57865	0.02982	0.03550	0.02308	55.84150	0.00316	0.00138	56.33704
Gasoline	Utility	72	0.68040	22.57200	0.58680	0.03024	0.03600	0.02340	56.62800	0.00320	0.00140	57.13052
Gasoline	Utility	73	0.68985	22.88550	0.59495	0.03066	0.03650	0.02373	57.41450	0.00325	0.00142	57.92400
Gasoline	Utility	74	0.69930	23.19900	0.60310	0.03108	0.03700	0.02405	58.20100	0.00329	0.00144	58.71748
Gasoline	Utility	75	0.70875	23.51250	0.61125	0.03150	0.03750	0.02438	58.98750	0.00334	0.00146	59.51096
Gasoline	Utility	76	0.71820	23.82600	0.61940	0.03192	0.03800	0.02470	59.77400	0.00338	0.00148	60.30444
Gasoline	Utility	77	0.72765	24.13950	0.62755	0.03234	0.03850	0.02503	60.56050	0.00343	0.00150	61.09792
Gasoline	Utility	78	0.73710	24.45300	0.63570	0.03276	0.03900	0.02535	61.34700	0.00347	0.00152	61.89140
Gasoline	Utility	79	0.74655	24.76650	0.64385	0.03318	0.03950	0.02568	62.13350	0.00352	0.00154	62.68488
Gasoline	Utility	80	0.75600	25.08000	0.65200	0.03360	0.04000	0.02600	62.92000	0.00356	0.00156	63.47836
Gasoline	Utility	81	0.76545	25.39350	0.66015	0.03402	0.04050	0.02633	63.70650	0.00360	0.00158	64.27184
Gasoline	Utility	82	0.77490	25.70700	0.66830	0.03444	0.04100	0.02665	64.49300	0.00365	0.00160	65.06532
Gasoline	Utility	83	0.78435	26.02050	0.67645	0.03486	0.04150	0.02698	65.27950	0.00369	0.00162	65.85880
Gasoline	Utility	84	0.79380	26.33400	0.68460	0.03528	0.04200	0.02730	66.06600	0.00374	0.00164	66.65228
Gasoline	Utility	85	0.80325	26.64750	0.69275	0.03570	0.04250	0.02763	66.85250	0.00378	0.00166	67.44576
Gasoline	Utility	86	0.81270	26.96100	0.70090	0.03612	0.04300	0.02795	67.63900	0.00383	0.00168	68.23924
Gasoline	Utility	87	0.82215	27.27450	0.70905	0.03654	0.04350	0.02828	68.42550	0.00387	0.00170	69.03272
Gasoline	Utility	88	0.83160	27.58800	0.71720	0.03696	0.04400	0.02860	69.21200	0.00392	0.00172	69.82620
Gasoline	Utility	89	0.84105	27.90150	0.72535	0.03738	0.04450	0.02893	69.99850	0.00396	0.00174	70.61968
Gasoline	Utility	90	0.85050	28.21500	0.73350	0.03780	0.04500	0.02925	70.78500	0.00401	0.00176	71.41316
Gasoline	Utility	91	0.85995	28.52850	0.74165	0.03822	0.04550	0.02958	71.57150	0.00405	0.00177	72.20663
Gasoline	Utility	92	0.86940	28.84200	0.74980	0.03864	0.04600	0.02990	72.35800	0.00409	0.00179	73.00011
Gasoline	Utility	93	0.87885	29.15550	0.75795	0.03906	0.04650	0.03023	73.14450	0.00414	0.00181	73.79359
Gasoline	Utility	94	0.88830	29.46900	0.76610	0.03948	0.04700	0.03055	73.93100	0.00418	0.00183	74.58707
Gasoline	Utility	95	0.89775	29.78250	0.77425	0.03990	0.04750	0.03088	74.71750	0.00423	0.00185	75.38055
Gasoline	Utility	96	0.90720	30.09600	0.78240	0.04032	0.04800	0.03120	75.50400	0.00427	0.00187	76.17403
Gasoline	Utility	97	0.91665	30.40950	0.79055	0.04074	0.04850	0.03153	76.29050	0.00432	0.00189	76.96751
Gasoline	Utility	98	0.92610	30.72300	0.79870	0.04116	0.04900	0.03185	77.07700	0.00436	0.00191	77.76099
Gasoline	Utility	99	0.93555	31.03650	0.80685	0.04158	0.04950	0.03218	77.86350	0.00441	0.00193	78.55447
Gasoline	Utility	100	0.94500	31.35000	0.81500	0.04200	0.05000	0.03250	78.65000	0.00445	0.00195	79.34795
Gasoline	Utility	101	0.95445	31.66350	0.82315	0.04242	0.05050	0.03283	79.43650	0.00449	0.00197	80.14143
Gasoline	Utility	102	0.96390	31.97700	0.83130	0.04284	0.05100	0.03315	80.22300	0.00454	0.00199	80.93491
Gasoline	Utility	103	0.97335	32.29050	0.83945	0.04326	0.05150	0.03348	81.00950	0.00458	0.00201	81.72839
Gasoline	Utility	104	0.98280	32.60400	0.84760	0.04368	0.05200	0.03380	81.79600	0.00463	0.00203	82.52187
Gasoline	Utility	105	0.99225	32.91750	0.85575	0.04410	0.05250	0.03413	82.58250	0.00467	0.00205	83.31535
Gasoline	Utility	106	1.00170	33.23100	0.86390	0.04452	0.05300	0.03445	83.36900	0.00472	0.00207	84.10883
Gasoline	Utility	107	1.01115	33.54450	0.87205	0.04494	0.05350	0.03478	84.15550	0.00476	0.00209	84.90231
Gasoline	Utility	108	1.02060	33.85800	0.88020	0.04536	0.05400	0.03510	84.94200	0.00481	0.00211	85.69579
Gasoline	Utility	109	1.03005	34.17150	0.88835	0.04578	0.05450	0.03543	85.72850	0.00485	0.00213	86.48927
Gasoline	Utility	110	1.03950	34.48500	0.89650	0.04620	0.05500	0.03575	86.51500	0.00490	0.00215	87.28275
Gasoline	Utility	111	1.04895	34.79850	0.90465	0.04662	0.05550	0.03608	87.30150	0.00494	0.00216	88.07622
Gasoline	Utility	112	1.05840	35.11200	0.91280	0.04704	0.05600	0.03640	88.08800	0.00498	0.00218	88.86970
Gasoline	Utility	113	1.06785	35.42550	0.92095	0.04746	0.05650	0.03673	88.87450	0.00503	0.00220	89.66318

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
Gasoline	Utility	114	1.07730	35.73900	0.92910	0.04788	0.05700	0.03705	89.66100	0.00507	0.00222	90.45666
Gasoline	Utility	115	1.08675	36.05250	0.93725	0.04830	0.05750	0.03738	90.44750	0.00512	0.00224	91.25014
Gasoline	Utility	116	1.09620	36.36600	0.94540	0.04872	0.05800	0.03770	91.23400	0.00516	0.00226	92.04362
Gasoline	Utility	117	1.10565	36.67950	0.95355	0.04914	0.05850	0.03803	92.02050	0.00521	0.00228	92.83710
Gasoline	Utility	118	1.11510	36.99300	0.96170	0.04956	0.05900	0.03835	92.80700	0.00525	0.00230	93.63058
Gasoline	Utility	119	1.12455	37.30650	0.96985	0.04998	0.05950	0.03868	93.59350	0.00530	0.00232	94.42406
Gasoline	Utility	120	1.13400	37.62000	0.97800	0.05040	0.06000	0.03900	94.38000	0.00534	0.00234	95.21754
Gasoline	Utility	121	1.14345	37.93350	0.98615	0.05082	0.06050	0.03933	95.16650	0.00538	0.00236	96.01102
Gasoline	Utility	122	1.15290	38.24700	0.99430	0.05124	0.06100	0.03965	95.95300	0.00543	0.00238	96.80450
Gasoline	Utility	123	1.16235	38.56050	1.00245	0.05166	0.06150	0.03998	96.73950	0.00547	0.00240	97.59798
Gasoline	Utility	124	1.17180	38.87400	1.01060	0.05208	0.06200	0.04030	97.52600	0.00552	0.00242	98.39146
Gasoline	Utility	125	1.18125	39.18750	1.01875	0.05250	0.06250	0.04063	98.31250	0.00556	0.00244	99.18494
Gasoline	Utility	126	1.19070	39.50100	1.02690	0.05292	0.06300	0.04095	99.09900	0.00561	0.00246	99.97842
Gasoline	Utility	127	1.20015	39.81450	1.03505	0.05334	0.06350	0.04128	99.88550	0.00565	0.00248	100.77190
Gasoline	Utility	128	1.20960	40.12800	1.04320	0.05376	0.06400	0.04160	100.67200	0.00570	0.00250	101.56538
Gasoline	Utility	129	1.21905	40.44150	1.05135	0.05418	0.06450	0.04193	101.45850	0.00574	0.00252	102.35886
Gasoline	Utility	130	1.22850	40.75500	1.05950	0.05460	0.06500	0.04225	102.24500	0.00579	0.00254	103.15234
Gasoline	Utility	131	1.23795	41.06850	1.06765	0.05502	0.06550	0.04258	103.03150	0.00583	0.00255	103.94581
Gasoline	Utility	132	1.24740	41.38200	1.07580	0.05544	0.06600	0.04290	103.81800	0.00587	0.00257	104.73929
Gasoline	Utility	133	1.25685	41.69550	1.08395	0.05586	0.06650	0.04323	104.60450	0.00592	0.00259	105.53277
Gasoline	Utility	134	1.26630	42.00900	1.09210	0.05628	0.06700	0.04355	105.39100	0.00596	0.00261	106.32625
Gasoline	Utility	135	1.27575	42.32250	1.10025	0.05670	0.06750	0.04388	106.17750	0.00601	0.00263	107.11973
Gasoline	Utility	136	1.28520	42.63600	1.10840	0.05712	0.06800	0.04420	106.96400	0.00605	0.00265	107.91321
Gasoline	Utility	137	1.29465	42.94950	1.11655	0.05754	0.06850	0.04453	107.75050	0.00610	0.00267	108.70669
Gasoline	Utility	138	1.30410	43.26300	1.12470	0.05796	0.06900	0.04485	108.53700	0.00614	0.00269	109.50017
Gasoline	Utility	139	1.31355	43.57650	1.13285	0.05838	0.06950	0.04518	109.32350	0.00619	0.00271	110.29365
Gasoline	Utility	140	1.32300	43.89000	1.14100	0.05880	0.07000	0.04550	110.11000	0.00623	0.00273	111.08713
Gasoline	Utility	141	1.33245	44.20350	1.14915	0.05922	0.07050	0.04583	110.89650	0.00627	0.00275	111.88061
Gasoline	Utility	142	1.34190	44.51700	1.15730	0.05964	0.07100	0.04615	111.68300	0.00632	0.00277	112.67409
Gasoline	Utility	143	1.35135	44.83050	1.16545	0.06006	0.07150	0.04648	112.46950	0.00636	0.00279	113.46757
Gasoline	Utility	144	1.36080	45.14400	1.17360	0.06048	0.07200	0.04680	113.25600	0.00641	0.00281	114.26105
Gasoline	Utility	145	1.37025	45.45750	1.18175	0.06090	0.07250	0.04713	114.04250	0.00645	0.00283	115.05453
Gasoline	Utility	146	1.37970	45.77100	1.18990	0.06132	0.07300	0.04745	114.82900	0.00650	0.00285	115.84801
Gasoline	Utility	147	1.38915	46.08450	1.19805	0.06174	0.07350	0.04778	115.61550	0.00654	0.00287	116.64149
Gasoline	Utility	148	1.39860	46.39800	1.20620	0.06216	0.07400	0.04810	116.40200	0.00659	0.00289	117.43497
Gasoline	Utility	149	1.40805	46.71150	1.21435	0.06258	0.07450	0.04843	117.18850	0.00663	0.00291	118.22845
Gasoline	Utility	150	1.41750	47.02500	1.22250	0.06300	0.07500	0.04875	117.97500	0.00668	0.00293	119.02193
Gasoline	Utility	151	1.42695	47.33850	1.23065	0.06342	0.07550	0.04908	118.76150	0.00672	0.00294	119.81540
Gasoline	Utility	152	1.43640	47.65200	1.23880	0.06384	0.07600	0.04940	119.54800	0.00676	0.00296	120.60888
Gasoline	Utility	153	1.44585	47.96550	1.24695	0.06426	0.07650	0.04973	120.33450	0.00681	0.00298	121.40236
Gasoline	Utility	154	1.45530	48.27900	1.25510	0.06468	0.07700	0.05005	121.12100	0.00685	0.00300	122.19584
Gasoline	Utility	155	1.46475	48.59250	1.26325	0.06510	0.07750	0.05038	121.90750	0.00690	0.00302	122.98932
Gasoline	Utility	156	1.47420	48.90600	1.27140	0.06552	0.07800	0.05070	122.69400	0.00694	0.00304	123.78280
Gasoline	Utility	157	1.48365	49.21950	1.27955	0.06594	0.07850	0.05103	123.48050	0.00699	0.00306	124.57628
Gasoline	Utility	158	1.49310	49.53300	1.28770	0.06636	0.07900	0.05135	124.26700	0.00703	0.00308	125.36976
Gasoline	Utility	159	1.50255	49.84650	1.29585	0.06678	0.07950	0.05168	125.05350	0.00708	0.00310	126.16324
Gasoline	Utility	160	1.51200	50.16000	1.30400	0.06720	0.08000	0.05200	125.84000	0.00712	0.00312	126.95672
Gasoline	Utility	161	1.52145	50.47350	1.31215	0.06762	0.08050	0.05233	126.62650	0.00716	0.00314	127.75020
Gasoline	Utility	162	1.53090	50.78700	1.32030	0.06804	0.08100	0.05265	127.41300	0.00721	0.00316	128.54368
Gasoline	Utility	163	1.54035	51.10050	1.32845	0.06846	0.08150	0.05298	128.19950	0.00725	0.00318	129.33716
Gasoline	Utility	164	1.54980	51.41400	1.33660	0.06888	0.08200	0.05330	128.98600	0.00730	0.00320	130.13064
Gasoline	Utility	165	1.55925	51.72750	1.34475	0.06930	0.08250	0.05363	129.77250	0.00734	0.00322	130.92412
Gasoline	Utility	166	1.56870	52.04100	1.35290	0.06972	0.08300	0.05395	130.55900	0.00739	0.00324	131.71760
Gasoline	Utility	167	1.57815	52.35450	1.36105	0.07014	0.08350	0.05428	131.34550	0.00743	0.00326	132.51108
Gasoline	Utility	168	1.58760	52.66800	1.36920	0.07056	0.08400	0.05460	132.13200	0.00748	0.00328	133.30456
Gasoline	Utility	169	1.59705	52.98150	1.37735	0.07098	0.08450	0.05493	132.91850	0.00752	0.00330	134.09804
Gasoline	Utility	170	1.60650	53.29500	1.38550	0.07140	0.08500	0.05525	133.70500	0.00757	0.00332	134.89152
Gasoline	Utility	171	1.61595	53.60850	1.39365	0.07182	0.08550	0.05558	134.49150	0.00761	0.00333	135.68499
Gasoline	Utility	172	1.62540	53.92200	1.40180	0.07224	0.08600	0.05590	135.27800	0.00765	0.00335	136.47847
Gasoline	Utility	173	1.63485	54.23550	1.40995	0.07266	0.08650	0.05623	136.06450	0.00770	0.00337	137.27195
Gasoline	Utility	174	1.64430	54.54900	1.41810	0.07308	0.08700	0.05655	136.85100	0.00774	0.00339	138.06543
Gasoline	Utility	175	1.65375	54.86250	1.42625	0.07350	0.08750	0.05688	137.63750	0.00779	0.00341	138.85891
Gasoline	Utility	176	1.66320	55.17600	1.43440	0.07392	0.08800	0.05720	138.42400	0.00783	0.00343	139.65239
Gasoline	Utility	177	1.67265	55.48950	1.44255	0.07434	0.08850	0.05753	139.21050	0.00788	0.00345	140.44587
Gasoline	Utility	178	1.68210	55.80300	1.45070	0.07476	0.08900	0.05785	139.99700	0.00792	0.00347	141.23935
Gasoline	Utility	179	1.69155	56.11650	1.45885	0.07518	0.08950	0.05818	140.78350	0.00797	0.00349	142.03283
Gasoline	Utility	180	1.70100	56.43000	1.46700	0.07560	0.09000	0.05850	141.57000	0.00801	0.00351	142.82631
Gasoline	Utility	181	1.71045	56.74350	1.47515	0.07602	0.09050	0.05883	142.35650	0.00805	0.00353	143.61979
Gasoline	Utility	182	1.71990	57.05700	1.48330	0.07644	0.09100	0.05915	143.14300	0.00810	0.00355	144.41327
Gasoline	Utility	183	1.72935	57.37050	1.49145	0.07686	0.09150	0.05948	143.92950	0.00814	0.00357	145.20675
Gasoline	Utility	184	1.73880	57.68400	1.49960	0.07728	0.09200	0.05980	144.71600	0.00819	0.00359	146.00023
Gasoline	Utility	185	1.74825	57.99750	1.50775	0.07770	0.09250	0.06013	145.50250	0.00823	0.00361	146.79371
Gasoline	Utility	186	1.75770	58.31100	1.51590	0.07812	0.09300	0.06045	146.28900	0.00828	0.00363	147.58719
Gasoline	Utility	187	1.76715	58.62450	1.52405	0.07854	0.09350	0.06078	147.07550	0.00832	0.00365	148.38067
Gasoline	Utility	188	1.77660	58.93800	1.53220	0.07896	0.09400	0.06110	147.86200	0.00837	0.00367	149.17415
Gasoline	Utility	189	1.78605	59.25150	1.54035	0.07938	0.09450	0.06143	148.64850	0.00841	0.00369	149.96763
Gasoline	Utility	190	1.79550	59.56500	1.54850	0.07980	0.09500	0.06175	149.43500	0.00846	0.00371	150.76111
Gasoline	Utility	191	1.80495	59.87850	1.55665	0.08022	0.09550	0.06208	150.22150	0.00850	0.00372	151.55458

Factors

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
Gasoline	Utility	192	1.81440	60.19200	1.56480	0.08064	0.09600	0.06240	151.00800	0.00854	0.00374	152.34806
Gasoline	Utility	193	1.82385	60.50550	1.57295	0.08106	0.09650	0.06273	151.79450	0.00859	0.00376	153.14154
Gasoline	Utility	194	1.83330	60.81900	1.58110	0.08148	0.09700	0.06305	152.58100	0.00863	0.00378	153.93502
Gasoline	Utility	195	1.84275	61.13250	1.58925	0.08190	0.09750	0.06338	153.36750	0.00868	0.00380	154.72850
Gasoline	Utility	196	1.85220	61.44600	1.59740	0.08232	0.09800	0.06370	154.15400	0.00872	0.00382	155.52198
Gasoline	Utility	197	1.86165	61.75950	1.60555	0.08274	0.09850	0.06403	154.94050	0.00877	0.00384	156.31546
Gasoline	Utility	198	1.87110	62.07300	1.61370	0.08316	0.09900	0.06435	155.72700	0.00881	0.00386	157.10894
Gasoline	Utility	199	1.88055	62.38650	1.62185	0.08358	0.09950	0.06468	156.51350	0.00886	0.00388	157.90242
Gasoline	Utility	200	1.89000	62.70000	1.63000	0.08400	0.10000	0.06500	157.30000	0.00890	0.00390	158.69590
Diesel	**Offroad**	**5.0**	**0.00444**	**0.03946**	**0.03255**	**0.00004**	**0.00395**	**0.00335**	**3.91200**	**0.00022**	**0.00010**	**3.94719**
Diesel	Offroad	5.1	0.00453	0.04025	0.03320	0.00004	0.00402	0.00342	3.99024	0.00023	0.00010	4.02614
Diesel	Offroad	5.2	0.00462	0.04103	0.03385	0.00004	0.00410	0.00349	4.06848	0.00023	0.00010	4.10508
Diesel	Offroad	5.3	0.00471	0.04182	0.03450	0.00004	0.00418	0.00356	4.14672	0.00024	0.00010	4.18402
Diesel	Offroad	5.4	0.00479	0.04261	0.03516	0.00004	0.00426	0.00362	4.22496	0.00024	0.00011	4.26297
Diesel	Offroad	5.5	0.00488	0.04340	0.03581	0.00004	0.00434	0.00369	4.30320	0.00025	0.00011	4.34191
Diesel	Offroad	5.6	0.00497	0.04419	0.03646	0.00004	0.00442	0.00376	4.38144	0.00025	0.00011	4.42085
Diesel	Offroad	5.7	0.00506	0.04498	0.03711	0.00004	0.00450	0.00382	4.45968	0.00025	0.00011	4.49980
Diesel	Offroad	5.8	0.00515	0.04577	0.03776	0.00004	0.00458	0.00389	4.53792	0.00026	0.00011	4.57874
Diesel	Offroad	5.9	0.00524	0.04656	0.03841	0.00004	0.00466	0.00396	4.61616	0.00026	0.00012	4.65769
Diesel	Offroad	6.0	0.00533	0.04735	0.03906	0.00004	0.00473	0.00402	4.69440	0.00027	0.00012	4.73663
Diesel	Offroad	6.1	0.00542	0.04814	0.03971	0.00005	0.00481	0.00409	4.77264	0.00027	0.00012	4.81557
Diesel	Offroad	6.2	0.00550	0.04893	0.04036	0.00005	0.00489	0.00416	4.85088	0.00028	0.00012	4.89452
Diesel	Offroad	6.3	0.00559	0.04972	0.04102	0.00005	0.00497	0.00423	4.92912	0.00028	0.00012	4.97346
Diesel	Offroad	6.4	0.00568	0.05050	0.04167	0.00005	0.00505	0.00429	5.00736	0.00029	0.00013	5.05240
Diesel	Offroad	6.5	0.00577	0.05129	0.04232	0.00005	0.00513	0.00436	5.08560	0.00029	0.00013	5.13135
Diesel	Offroad	6.6	0.00586	0.05208	0.04297	0.00005	0.00521	0.00443	5.16384	0.00029	0.00013	5.21029
Diesel	Offroad	6.7	0.00595	0.05287	0.04362	0.00005	0.00529	0.00449	5.24208	0.00030	0.00013	5.28924
Diesel	Offroad	6.8	0.00604	0.05366	0.04427	0.00005	0.00537	0.00456	5.32032	0.00030	0.00013	5.36818
Diesel	Offroad	6.9	0.00613	0.05445	0.04492	0.00005	0.00545	0.00463	5.39856	0.00031	0.00014	5.44712
Diesel	Offroad	7.0	0.00621	0.05524	0.04557	0.00005	0.00552	0.00470	5.47680	0.00031	0.00014	5.52607
Diesel	Offroad	7.1	0.00630	0.05603	0.04622	0.00005	0.00560	0.00476	5.55504	0.00032	0.00014	5.60501
Diesel	Offroad	7.2	0.00639	0.05682	0.04687	0.00005	0.00568	0.00483	5.63328	0.00032	0.00014	5.68396
Diesel	Offroad	7.3	0.00648	0.05761	0.04753	0.00005	0.00576	0.00490	5.71152	0.00033	0.00014	5.76290
Diesel	Offroad	7.4	0.00657	0.05840	0.04818	0.00006	0.00584	0.00496	5.78976	0.00033	0.00015	5.84184
Diesel	Offroad	7.5	0.00666	0.05918	0.04883	0.00006	0.00592	0.00503	5.86800	0.00033	0.00015	5.92079
Diesel	Offroad	7.6	0.00675	0.05997	0.04948	0.00006	0.00600	0.00510	5.94624	0.00034	0.00015	5.99973
Diesel	Offroad	7.7	0.00684	0.06076	0.05013	0.00006	0.00608	0.00516	6.02448	0.00034	0.00015	6.07867
Diesel	Offroad	7.8	0.00692	0.06155	0.05078	0.00006	0.00616	0.00523	6.10272	0.00035	0.00015	6.15762
Diesel	Offroad	7.9	0.00701	0.06234	0.05143	0.00006	0.00623	0.00530	6.18096	0.00035	0.00016	6.23656
Diesel	Offroad	8.0	0.00710	0.06313	0.05208	0.00006	0.00631	0.00537	6.25920	0.00036	0.00016	6.31551
Diesel	Offroad	8.1	0.00719	0.06392	0.05273	0.00006	0.00639	0.00543	6.33744	0.00036	0.00016	6.39445
Diesel	Offroad	8.2	0.00728	0.06471	0.05338	0.00006	0.00647	0.00550	6.41568	0.00037	0.00016	6.47339
Diesel	Offroad	8.3	0.00737	0.06550	0.05404	0.00006	0.00655	0.00557	6.49392	0.00037	0.00016	6.55234
Diesel	Offroad	8.4	0.00746	0.06629	0.05469	0.00006	0.00663	0.00563	6.57216	0.00037	0.00017	6.63128
Diesel	Offroad	8.5	0.00755	0.06708	0.05534	0.00006	0.00671	0.00570	6.65040	0.00038	0.00017	6.71023
Diesel	Offroad	8.6	0.00763	0.06787	0.05599	0.00006	0.00679	0.00577	6.72864	0.00038	0.00017	6.78917
Diesel	Offroad	8.7	0.00772	0.06865	0.05664	0.00006	0.00687	0.00584	6.80688	0.00039	0.00017	6.86811
Diesel	Offroad	8.8	0.00781	0.06944	0.05729	0.00007	0.00694	0.00590	6.88512	0.00039	0.00017	6.94706
Diesel	Offroad	8.9	0.00790	0.07023	0.05794	0.00007	0.00702	0.00597	6.96336	0.00040	0.00018	7.02600
Diesel	Offroad	9.0	0.00799	0.07102	0.05859	0.00007	0.00710	0.00604	7.04160	0.00040	0.00018	7.10494
Diesel	Offroad	9.1	0.00808	0.07181	0.05924	0.00007	0.00718	0.00610	7.11984	0.00041	0.00018	7.18389
Diesel	Offroad	9.2	0.00817	0.07260	0.05990	0.00007	0.00726	0.00617	7.19808	0.00041	0.00018	7.26283
Diesel	Offroad	9.3	0.00826	0.07339	0.06055	0.00007	0.00734	0.00624	7.27632	0.00042	0.00018	7.34178
Diesel	Offroad	9.4	0.00835	0.07418	0.06120	0.00007	0.00742	0.00631	7.35456	0.00042	0.00018	7.42072
Diesel	Offroad	9.5	0.00843	0.07497	0.06185	0.00007	0.00750	0.00637	7.43280	0.00042	0.00019	7.49966
Diesel	Offroad	9.6	0.00852	0.07576	0.06250	0.00007	0.00758	0.00644	7.51104	0.00043	0.00019	7.57861
Diesel	Offroad	9.7	0.00861	0.07655	0.06315	0.00007	0.00765	0.00651	7.58928	0.00043	0.00019	7.65755
Diesel	Offroad	9.8	0.00870	0.07733	0.06380	0.00007	0.00773	0.00657	7.66752	0.00044	0.00019	7.73649
Diesel	Offroad	9.9	0.00879	0.07812	0.06445	0.00007	0.00781	0.00664	7.74576	0.00044	0.00019	7.81544
Diesel	**Offroad**	**10**	**0.00888**	**0.06510**	**0.06510**	**0.00007**	**0.00789**	**0.00671**	**7.82400**	**0.00045**	**0.00020**	**7.89438**
Diesel	Offroad	11	0.00977	0.07161	0.07161	0.00008	0.00868	0.00738	8.60640	0.00049	0.00022	8.68382
Diesel	Offroad	12	0.01065	0.07812	0.07812	0.00009	0.00947	0.00805	9.38880	0.00054	0.00024	9.47326
Diesel	Offroad	13	0.01154	0.08463	0.08463	0.00010	0.01026	0.00872	10.17120	0.00058	0.00026	10.26270
Diesel	Offroad	14	0.01243	0.09114	0.09114	0.00010	0.01105	0.00939	10.95360	0.00062	0.00028	11.05214
Diesel	Offroad	15	0.01332	0.09765	0.09765	0.00011	0.01184	0.01006	11.73600	0.00067	0.00030	11.84157
Diesel	Offroad	16	0.01420	0.10417	0.10417	0.00012	0.01263	0.01073	12.51840	0.00071	0.00031	12.63101
Diesel	Offroad	17	0.01509	0.11068	0.11068	0.00013	0.01342	0.01140	13.30080	0.00076	0.00033	13.42045
Diesel	Offroad	18	0.01598	0.11719	0.11719	0.00013	0.01420	0.01207	14.08320	0.00080	0.00035	14.20989
Diesel	Offroad	19	0.01687	0.12370	0.12370	0.00014	0.01499	0.01274	14.86560	0.00085	0.00037	14.99933
Diesel	Offroad	20	0.01776	0.13021	0.13021	0.00015	0.01578	0.01342	15.64800	0.00089	0.00039	15.78876
Diesel	Offroad	21	0.01864	0.13672	0.13672	0.00016	0.01657	0.01409	16.43040	0.00094	0.00041	16.57820
Diesel	Offroad	22	0.01953	0.14323	0.14323	0.00016	0.01736	0.01476	17.21280	0.00098	0.00043	17.36764
Diesel	Offroad	23	0.02042	0.14974	0.14974	0.00017	0.01815	0.01543	17.99520	0.00103	0.00045	18.15708
Diesel	Offroad	24	0.02131	0.15625	0.15625	0.00018	0.01894	0.01610	18.77760	0.00107	0.00047	18.94652
Diesel	**Offroad**	**25**	**0.02219**	**0.13563**	**0.16276**	**0.00016**	**0.01480**	**0.01258**	**17.11500**	**0.00098**	**0.00043**	**17.26896**
Diesel	Offroad	26	0.02308	0.14106	0.16927	0.00017	0.01539	0.01308	17.79960	0.00102	0.00045	17.95972
Diesel	Offroad	27	0.02397	0.14648	0.17578	0.00018	0.01598	0.01358	18.48420	0.00105	0.00046	18.65048
Diesel	Offroad	28	0.02486	0.15191	0.18229	0.00018	0.01657	0.01409	19.16880	0.00109	0.00048	19.34124

Factors

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
Diesel	Offroad	29	0.02575	0.15733	0.18880	0.00019	0.01716	0.01459	19.85340	0.00113	0.00050	20.03200
Diesel	Offroad	30	0.02663	0.16276	0.19531	0.00020	0.01776	0.01509	20.53800	0.00117	0.00052	20.72275
Diesel	Offroad	31	0.02752	0.16818	0.20182	0.00020	0.01835	0.01560	21.22260	0.00121	0.00053	21.41351
Diesel	Offroad	32	0.02841	0.17361	0.20833	0.00021	0.01894	0.01610	21.90720	0.00125	0.00055	22.10427
Diesel	Offroad	33	0.02930	0.17903	0.21484	0.00022	0.01953	0.01660	22.59180	0.00129	0.00057	22.79503
Diesel	Offroad	34	0.03018	0.18446	0.22135	0.00022	0.02012	0.01710	23.27640	0.00133	0.00059	23.48579
Diesel	Offroad	35	0.03107	0.18988	0.22786	0.00023	0.02071	0.01761	23.96100	0.00137	0.00060	24.17655
Diesel	Offroad	36	0.03196	0.19531	0.23437	0.00024	0.02131	0.01811	24.64560	0.00141	0.00062	24.86730
Diesel	Offroad	37	0.03285	0.20074	0.24088	0.00024	0.02190	0.01861	25.33020	0.00145	0.00064	25.55806
Diesel	Offroad	38	0.03374	0.20616	0.24739	0.00025	0.02249	0.01912	26.01480	0.00148	0.00065	26.24882
Diesel	Offroad	39	0.03462	0.21159	0.25390	0.00025	0.02308	0.01962	26.69940	0.00152	0.00067	26.93958
Diesel	Offroad	40	0.03551	0.21701	0.26041	0.00026	0.02367	0.02012	27.38400	0.00156	0.00069	27.63034
Diesel	Offroad	41	0.03640	0.22244	0.26692	0.00027	0.02427	0.02063	28.06860	0.00160	0.00071	28.32110
Diesel	Offroad	42	0.03729	0.22786	0.27343	0.00027	0.02486	0.02113	28.75320	0.00164	0.00072	29.01186
Diesel	Offroad	43	0.03817	0.23329	0.27994	0.00028	0.02545	0.02163	29.43780	0.00168	0.00074	29.70261
Diesel	Offroad	44	0.03906	0.23871	0.28645	0.00029	0.02604	0.02214	30.12240	0.00172	0.00076	30.39337
Diesel	Offroad	45	0.03995	0.24414	0.29296	0.00029	0.02663	0.02264	30.80700	0.00176	0.00077	31.08413
Diesel	Offroad	46	0.04084	0.24956	0.29948	0.00030	0.02723	0.02314	31.49160	0.00180	0.00079	31.77489
Diesel	Offroad	47	0.04173	0.25499	0.30599	0.00031	0.02782	0.02364	32.17620	0.00184	0.00081	32.46565
Diesel	Offroad	48	0.04261	0.26041	0.31250	0.00031	0.02841	0.02415	32.86080	0.00187	0.00083	33.15641
Diesel	Offroad	49	0.04350	0.26584	0.31901	0.00032	0.02900	0.02465	33.54540	0.00191	0.00084	33.84716
Diesel	**Offroad**	**50**	**0.04439**	**0.24660**	**0.32552**	**0.00033**	**0.01973**	**0.01677**	**34.23000**	**0.00195**	**0.00086**	**34.53792**
Diesel	Offroad	51	0.04528	0.25154	0.33203	0.00033	0.02012	0.01710	34.91460	0.00199	0.00088	35.22868
Diesel	Offroad	52	0.04616	0.25647	0.33854	0.00034	0.02052	0.01744	35.59920	0.00203	0.00090	35.91944
Diesel	Offroad	53	0.04705	0.26140	0.34505	0.00035	0.02091	0.01778	36.28380	0.00207	0.00091	36.61020
Diesel	Offroad	54	0.04794	0.26633	0.35156	0.00035	0.02131	0.01811	36.96840	0.00211	0.00093	37.30096
Diesel	Offroad	55	0.04883	0.27126	0.35807	0.00036	0.02170	0.01845	37.65300	0.00215	0.00095	37.99172
Diesel	Offroad	56	0.04972	0.27620	0.36458	0.00037	0.02210	0.01878	38.33760	0.00219	0.00096	38.68247
Diesel	Offroad	57	0.05060	0.28113	0.37109	0.00037	0.02249	0.01912	39.02220	0.00223	0.00098	39.37323
Diesel	Offroad	58	0.05149	0.28606	0.37760	0.00038	0.02288	0.01945	39.70680	0.00227	0.00100	40.06399
Diesel	Offroad	59	0.05238	0.29099	0.38411	0.00039	0.02328	0.01979	40.39140	0.00230	0.00102	40.75475
Diesel	Offroad	60	0.05327	0.29592	0.39062	0.00039	0.02367	0.02012	41.07600	0.00234	0.00103	41.44551
Diesel	Offroad	61	0.05415	0.30086	0.39713	0.00040	0.02407	0.02046	41.76060	0.00238	0.00105	42.13627
Diesel	Offroad	62	0.05504	0.30579	0.40364	0.00040	0.02446	0.02079	42.44520	0.00242	0.00107	42.82702
Diesel	Offroad	63	0.05593	0.31072	0.41015	0.00041	0.02486	0.02113	43.12980	0.00246	0.00108	43.51778
Diesel	Offroad	64	0.05682	0.31565	0.41666	0.00042	0.02525	0.02146	43.81440	0.00250	0.00110	44.20854
Diesel	Offroad	65	0.05771	0.32058	0.42317	0.00042	0.02565	0.02180	44.49900	0.00254	0.00112	44.89930
Diesel	Offroad	66	0.05859	0.32552	0.42968	0.00043	0.02604	0.02214	45.18360	0.00258	0.00114	45.59006
Diesel	Offroad	67	0.05948	0.33045	0.43619	0.00044	0.02644	0.02247	45.86820	0.00262	0.00115	46.28082
Diesel	Offroad	68	0.06037	0.33538	0.44270	0.00044	0.02683	0.02281	46.55280	0.00266	0.00117	46.97158
Diesel	Offroad	69	0.06126	0.34031	0.44921	0.00045	0.02723	0.02314	47.23740	0.00270	0.00119	47.66233
Diesel	Offroad	70	0.06214	0.34524	0.45572	0.00046	0.02762	0.02348	47.92200	0.00273	0.00121	48.35309
Diesel	Offroad	71	0.06303	0.35018	0.46223	0.00046	0.02801	0.02381	48.60660	0.00277	0.00122	49.04385
Diesel	Offroad	72	0.06392	0.35511	0.46874	0.00047	0.02841	0.02415	49.29120	0.00281	0.00124	49.73461
Diesel	Offroad	73	0.06481	0.36004	0.47525	0.00048	0.02880	0.02448	49.97580	0.00285	0.00126	50.42537
Diesel	Offroad	74	0.06570	0.36497	0.48176	0.00048	0.02920	0.02482	50.66040	0.00289	0.00127	51.11613
Diesel	**Offroad**	**75**	**0.06658**	**0.36991**	**0.48827**	**0.00049**	**0.02959**	**0.02515**	**51.34500**	**0.00293**	**0.00129**	**51.80688**
Diesel	Offroad	76	0.06747	0.37484	0.49479	0.00050	0.02999	0.02549	52.02960	0.00297	0.00131	52.49764
Diesel	Offroad	77	0.06836	0.37977	0.50130	0.00050	0.03038	0.02582	52.71420	0.00301	0.00133	53.18840
Diesel	Offroad	78	0.06925	0.38470	0.50781	0.00051	0.03078	0.02616	53.39880	0.00305	0.00134	53.87916
Diesel	Offroad	79	0.07013	0.38963	0.51432	0.00052	0.03117	0.02650	54.08340	0.00309	0.00136	54.56992
Diesel	Offroad	80	0.07102	0.39457	0.52083	0.00052	0.03157	0.02683	54.76800	0.00312	0.00138	55.26068
Diesel	Offroad	81	0.07191	0.39950	0.52734	0.00053	0.03196	0.02717	55.45260	0.00316	0.00139	55.95144
Diesel	Offroad	82	0.07280	0.40443	0.53385	0.00054	0.03235	0.02750	56.13720	0.00320	0.00141	56.64219
Diesel	Offroad	83	0.07369	0.40936	0.54036	0.00054	0.03275	0.02784	56.82180	0.00324	0.00143	57.33295
Diesel	Offroad	84	0.07457	0.41429	0.54687	0.00055	0.03314	0.02817	57.50640	0.00328	0.00145	58.02371
Diesel	Offroad	85	0.07546	0.41923	0.55338	0.00055	0.03354	0.02851	58.19100	0.00332	0.00146	58.71447
Diesel	Offroad	86	0.07635	0.42416	0.55989	0.00056	0.03393	0.02884	58.87560	0.00336	0.00148	59.40523
Diesel	Offroad	87	0.07724	0.42909	0.56640	0.00057	0.03433	0.02918	59.56020	0.00340	0.00150	60.09599
Diesel	Offroad	88	0.07812	0.43402	0.57291	0.00057	0.03472	0.02951	60.24480	0.00344	0.00152	60.78674
Diesel	Offroad	89	0.07901	0.43895	0.57942	0.00058	0.03512	0.02985	60.92940	0.00348	0.00153	61.47750
Diesel	Offroad	90	0.07990	0.44389	0.58593	0.00059	0.03551	0.03018	61.61400	0.00352	0.00155	62.16826
Diesel	Offroad	91	0.08079	0.44882	0.59244	0.00059	0.03591	0.03052	62.29860	0.00355	0.00157	62.85902
Diesel	Offroad	92	0.08168	0.45375	0.59895	0.00060	0.03630	0.03086	62.98320	0.00359	0.00158	63.54978
Diesel	Offroad	93	0.08256	0.45868	0.60546	0.00061	0.03669	0.03119	63.66780	0.00363	0.00160	64.24054
Diesel	Offroad	94	0.08345	0.46361	0.61197	0.00061	0.03709	0.03153	64.35240	0.00367	0.00162	64.93130
Diesel	Offroad	95	0.08434	0.46855	0.61848	0.00062	0.03748	0.03186	65.03700	0.00371	0.00164	65.62205
Diesel	Offroad	96	0.08523	0.47348	0.62499	0.00063	0.03788	0.03220	65.72160	0.00375	0.00165	66.31281
Diesel	Offroad	97	0.08611	0.47841	0.63150	0.00063	0.03827	0.03253	66.40620	0.00379	0.00167	67.00357
Diesel	Offroad	98	0.08700	0.48334	0.63801	0.00064	0.03867	0.03287	67.09080	0.00383	0.00169	67.69433
Diesel	Offroad	99	0.08789	0.48827	0.64452	0.00065	0.03906	0.03320	67.77540	0.00387	0.00170	68.38509
Diesel	**Offroad**	**100**	**0.07812**	**0.49321**	**0.57291**	**0.00065**	**0.02959**	**0.02515**	**68.46000**	**0.00391**	**0.00172**	**69.07585**
Diesel	Offroad	101	0.07891	0.49814	0.57864	0.00066	0.02989	0.02541	69.14460	0.00395	0.00174	69.76660
Diesel	Offroad	102	0.07969	0.50307	0.58437	0.00067	0.03018	0.02566	69.82920	0.00398	0.00176	70.45736
Diesel	Offroad	103	0.08047	0.50800	0.59010	0.00067	0.03048	0.02591	70.51380	0.00402	0.00177	71.14812
Diesel	Offroad	104	0.08125	0.51294	0.59583	0.00068	0.03078	0.02616	71.19840	0.00406	0.00179	71.83888
Diesel	Offroad	105	0.08203	0.51787	0.60155	0.00069	0.03107	0.02641	71.88300	0.00410	0.00181	72.52964
Diesel	Offroad	106	0.08281	0.52280	0.60728	0.00069	0.03137	0.02666	72.56760	0.00414	0.00183	73.22040

Factors

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
Diesel	Offroad	107	0.08359	0.52773	0.61301	0.00070	0.03166	0.02691	73.25220	0.00418	0.00184	73.91116
Diesel	Offroad	108	0.08437	0.53266	0.61874	0.00071	0.03196	0.02717	73.93680	0.00422	0.00186	74.60191
Diesel	Offroad	109	0.08516	0.53760	0.62447	0.00071	0.03226	0.02742	74.62140	0.00426	0.00188	75.29267
Diesel	Offroad	110	0.08594	0.54253	0.63020	0.00072	0.03255	0.02767	75.30600	0.00430	0.00189	75.98343
Diesel	Offroad	111	0.08672	0.54746	0.63593	0.00072	0.03285	0.02792	75.99060	0.00434	0.00191	76.67419
Diesel	Offroad	112	0.08750	0.55239	0.64166	0.00073	0.03314	0.02817	76.67520	0.00437	0.00193	77.36495
Diesel	Offroad	113	0.08828	0.55732	0.64739	0.00074	0.03344	0.02842	77.35980	0.00441	0.00195	78.05571
Diesel	Offroad	114	0.08906	0.56226	0.65312	0.00074	0.03374	0.02868	78.04440	0.00445	0.00196	78.74646
Diesel	Offroad	115	0.08984	0.56719	0.65885	0.00075	0.03403	0.02893	78.72900	0.00449	0.00198	79.43722
Diesel	Offroad	116	0.09062	0.57212	0.66457	0.00076	0.03433	0.02918	79.41360	0.00453	0.00200	80.12798
Diesel	Offroad	117	0.09141	0.57705	0.67030	0.00076	0.03462	0.02943	80.09820	0.00457	0.00201	80.81874
Diesel	Offroad	118	0.09219	0.58198	0.67603	0.00077	0.03492	0.02968	80.78280	0.00461	0.00203	81.50950
Diesel	Offroad	119	0.09297	0.58692	0.68176	0.00078	0.03521	0.02993	81.46740	0.00465	0.00205	82.20026
Diesel	Offroad	120	0.09375	0.59185	0.68749	0.00078	0.03551	0.03018	82.15200	0.00469	0.00207	82.89102
Diesel	Offroad	121	0.09453	0.59678	0.69322	0.00079	0.03581	0.03044	82.83660	0.00473	0.00208	83.58177
Diesel	Offroad	122	0.09531	0.60171	0.69895	0.00080	0.03610	0.03069	83.52120	0.00477	0.00210	84.27253
Diesel	Offroad	123	0.09609	0.60664	0.70468	0.00080	0.03640	0.03094	84.20580	0.00480	0.00212	84.96329
Diesel	Offroad	124	0.09687	0.61158	0.71041	0.00081	0.03669	0.03119	84.89040	0.00484	0.00214	85.65405
Diesel	Offroad	125	0.09765	0.61651	0.71614	0.00082	0.03699	0.03144	85.57500	0.00488	0.00215	86.34481
Diesel	Offroad	126	0.09844	0.62144	0.72187	0.00082	0.03729	0.03169	86.25960	0.00492	0.00217	87.03557
Diesel	Offroad	127	0.09922	0.62637	0.72759	0.00083	0.03758	0.03195	86.94420	0.00496	0.00219	87.72632
Diesel	Offroad	128	0.10000	0.63130	0.73332	0.00084	0.03788	0.03220	87.62880	0.00500	0.00220	88.41708
Diesel	Offroad	129	0.10078	0.63624	0.73905	0.00084	0.03817	0.03245	88.31340	0.00504	0.00222	89.10784
Diesel	Offroad	130	0.10156	0.64117	0.74478	0.00085	0.03847	0.03270	88.99800	0.00508	0.00224	89.79860
Diesel	Offroad	131	0.10234	0.64610	0.75051	0.00086	0.03877	0.03295	89.68260	0.00512	0.00226	90.48936
Diesel	Offroad	132	0.10312	0.65103	0.75624	0.00086	0.03906	0.03320	90.36720	0.00516	0.00227	91.18012
Diesel	Offroad	133	0.10390	0.65596	0.76197	0.00087	0.03936	0.03345	91.05180	0.00519	0.00229	91.87088
Diesel	Offroad	134	0.10469	0.66090	0.76770	0.00087	0.03965	0.03371	91.73640	0.00523	0.00231	92.56163
Diesel	Offroad	135	0.10547	0.66583	0.77343	0.00088	0.03995	0.03396	92.42100	0.00527	0.00232	93.25239
Diesel	Offroad	136	0.10625	0.67076	0.77916	0.00089	0.04025	0.03421	93.10560	0.00531	0.00234	93.94315
Diesel	Offroad	137	0.10703	0.67569	0.78489	0.00089	0.04054	0.03446	93.79020	0.00535	0.00236	94.63391
Diesel	Offroad	138	0.10781	0.68063	0.79061	0.00090	0.04084	0.03471	94.47480	0.00539	0.00238	95.32467
Diesel	Offroad	139	0.10859	0.68556	0.79634	0.00091	0.04113	0.03496	95.15940	0.00543	0.00239	96.01543
Diesel	Offroad	140	0.10937	0.69049	0.80207	0.00091	0.04143	0.03521	95.84400	0.00547	0.00241	96.70618
Diesel	Offroad	141	0.11015	0.69542	0.80780	0.00092	0.04173	0.03547	96.52860	0.00551	0.00243	97.39694
Diesel	Offroad	142	0.11094	0.70035	0.81353	0.00093	0.04202	0.03572	97.21320	0.00555	0.00245	98.08770
Diesel	Offroad	143	0.11172	0.70529	0.81926	0.00093	0.04232	0.03597	97.89780	0.00559	0.00246	98.77846
Diesel	Offroad	144	0.11250	0.71022	0.82499	0.00094	0.04261	0.03622	98.58240	0.00562	0.00248	99.46922
Diesel	Offroad	145	0.11328	0.71515	0.83072	0.00095	0.04291	0.03647	99.26700	0.00566	0.00250	100.15998
Diesel	Offroad	146	0.11406	0.72008	0.83645	0.00095	0.04320	0.03672	99.95160	0.00570	0.00251	100.85074
Diesel	Offroad	147	0.11484	0.72501	0.84218	0.00096	0.04350	0.03698	100.63620	0.00574	0.00253	101.54149
Diesel	Offroad	148	0.11562	0.72995	0.84791	0.00097	0.04380	0.03723	101.32080	0.00578	0.00255	102.23225
Diesel	Offroad	149	0.11640	0.73488	0.85363	0.00097	0.04409	0.03748	102.00540	0.00582	0.00257	102.92301
Diesel	Offroad	150	0.11719	0.73981	0.85936	0.00098	0.04439	0.03773	102.69000	0.00586	0.00258	103.61377
Diesel	Offroad	151	0.11797	0.74474	0.86509	0.00099	0.04468	0.03798	103.37460	0.00590	0.00260	104.30453
Diesel	Offroad	152	0.11875	0.74967	0.87082	0.00099	0.04498	0.03823	104.05920	0.00594	0.00262	104.99529
Diesel	Offroad	153	0.11953	0.75461	0.87655	0.00100	0.04528	0.03848	104.74380	0.00598	0.00263	105.68604
Diesel	Offroad	154	0.12031	0.75954	0.88228	0.00101	0.04557	0.03874	105.42840	0.00602	0.00265	106.37680
Diesel	Offroad	155	0.12109	0.76447	0.88801	0.00101	0.04587	0.03899	106.11300	0.00605	0.00267	107.06756
Diesel	Offroad	156	0.12187	0.76940	0.89374	0.00102	0.04616	0.03924	106.79760	0.00609	0.00269	107.75832
Diesel	Offroad	157	0.12265	0.77433	0.89947	0.00102	0.04646	0.03949	107.48220	0.00613	0.00270	108.44908
Diesel	Offroad	158	0.12344	0.77927	0.90520	0.00103	0.04676	0.03974	108.16680	0.00617	0.00272	109.13984
Diesel	Offroad	159	0.12422	0.78420	0.91093	0.00104	0.04705	0.03999	108.85140	0.00621	0.00274	109.83060
Diesel	Offroad	160	0.12500	0.78913	0.91665	0.00104	0.04735	0.04025	109.53600	0.00625	0.00276	110.52135
Diesel	Offroad	161	0.12578	0.79406	0.92238	0.00105	0.04764	0.04050	110.22060	0.00629	0.00277	111.21211
Diesel	Offroad	162	0.12656	0.79899	0.92811	0.00106	0.04794	0.04075	110.90520	0.00633	0.00279	111.90287
Diesel	Offroad	163	0.12734	0.80393	0.93384	0.00106	0.04824	0.04100	111.58980	0.00637	0.00281	112.59363
Diesel	Offroad	164	0.12812	0.80886	0.93957	0.00107	0.04853	0.04125	112.27440	0.00641	0.00282	113.28439
Diesel	Offroad	165	0.12890	0.81379	0.94530	0.00108	0.04883	0.04150	112.95900	0.00644	0.00284	113.97515
Diesel	Offroad	166	0.12969	0.81872	0.95103	0.00108	0.04912	0.04175	113.64360	0.00648	0.00286	114.66590
Diesel	Offroad	167	0.13047	0.82366	0.95676	0.00109	0.04942	0.04201	114.32820	0.00652	0.00288	115.35666
Diesel	Offroad	168	0.13125	0.82859	0.96249	0.00110	0.04972	0.04226	115.01280	0.00656	0.00289	116.04742
Diesel	Offroad	169	0.13203	0.83352	0.96822	0.00110	0.05001	0.04251	115.69740	0.00660	0.00291	116.73818
Diesel	Offroad	170	0.13281	0.83845	0.97395	0.00111	0.05031	0.04276	116.38200	0.00664	0.00293	117.42894
Diesel	Offroad	171	0.13359	0.84338	0.97967	0.00112	0.05060	0.04301	117.06660	0.00668	0.00294	118.11970
Diesel	Offroad	172	0.13437	0.84832	0.98540	0.00112	0.05090	0.04326	117.75120	0.00672	0.00296	118.81046
Diesel	Offroad	173	0.13515	0.85325	0.99113	0.00113	0.05119	0.04352	118.43580	0.00676	0.00298	119.50121
Diesel	Offroad	174	0.13594	0.85818	0.99686	0.00114	0.05149	0.04377	119.12040	0.00680	0.00300	120.19197
Diesel	**Offroad**	**175**	**0.13672**	**0.60418**	**1.00259**	**0.00114**	**0.03452**	**0.02935**	**119.80500**	**0.00684**	**0.00301**	**120.88273**
Diesel	Offroad	176	0.13750	0.60763	1.00832	0.00115	0.03472	0.02951	120.48960	0.00687	0.00303	121.57349
Diesel	Offroad	177	0.13828	0.61108	1.01405	0.00116	0.03492	0.02968	121.17420	0.00691	0.00305	122.26425
Diesel	Offroad	178	0.13906	0.61454	1.01978	0.00116	0.03512	0.02985	121.85880	0.00695	0.00307	122.95501
Diesel	Offroad	179	0.13984	0.61799	1.02551	0.00117	0.03531	0.03002	122.54340	0.00699	0.00308	123.64576
Diesel	Offroad	180	0.14062	0.62144	1.03124	0.00118	0.03551	0.03018	123.22800	0.00703	0.00310	124.33652
Diesel	Offroad	181	0.14140	0.62489	1.03697	0.00118	0.03571	0.03035	123.91260	0.00707	0.00312	125.02728
Diesel	Offroad	182	0.14219	0.62835	1.04269	0.00119	0.03591	0.03052	124.59720	0.00711	0.00313	125.71804
Diesel	Offroad	183	0.14297	0.63180	1.04842	0.00119	0.03610	0.03069	125.28180	0.00715	0.00315	126.40880
Diesel	Offroad	184	0.14375	0.63525	1.05415	0.00120	0.03630	0.03086	125.96640	0.00719	0.00317	127.09956

Factors

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
Diesel	Offroad	185	0.14453	0.63870	1.05988	0.00121	0.03650	0.03102	126.65100	0.00723	0.00319	127.79032
Diesel	Offroad	186	0.14531	0.64216	1.06561	0.00121	0.03669	0.03119	127.33560	0.00727	0.00320	128.48107
Diesel	Offroad	187	0.14609	0.64561	1.07134	0.00122	0.03689	0.03136	128.02020	0.00730	0.00322	129.17183
Diesel	Offroad	188	0.14687	0.64906	1.07707	0.00123	0.03709	0.03153	128.70480	0.00734	0.00324	129.86259
Diesel	Offroad	189	0.14765	0.65251	1.08280	0.00123	0.03729	0.03169	129.38940	0.00738	0.00325	130.55335
Diesel	Offroad	190	0.14844	0.65596	1.08853	0.00124	0.03748	0.03186	130.07400	0.00742	0.00327	131.24411
Diesel	Offroad	191	0.14922	0.65942	1.09426	0.00125	0.03768	0.03203	130.75860	0.00746	0.00329	131.93487
Diesel	Offroad	192	0.15000	0.66287	1.09999	0.00125	0.03788	0.03220	131.44320	0.00750	0.00331	132.62562
Diesel	Offroad	193	0.15078	0.66632	1.10571	0.00126	0.03808	0.03236	132.12780	0.00754	0.00332	133.31638
Diesel	Offroad	194	0.15156	0.66977	1.11144	0.00127	0.03827	0.03253	132.81240	0.00758	0.00334	134.00714
Diesel	Offroad	195	0.15234	0.67323	1.11717	0.00127	0.03847	0.03270	133.49700	0.00762	0.00336	134.69790
Diesel	Offroad	196	0.15312	0.67668	1.12290	0.00128	0.03867	0.03287	134.18160	0.00766	0.00338	135.38866
Diesel	Offroad	197	0.15390	0.68013	1.12863	0.00129	0.03886	0.03303	134.86620	0.00769	0.00339	136.07942
Diesel	Offroad	198	0.15469	0.68358	1.13436	0.00129	0.03906	0.03320	135.55080	0.00773	0.00341	136.77018
Diesel	Offroad	199	0.15547	0.68704	1.14009	0.00130	0.03926	0.03337	136.23540	0.00777	0.00343	137.46093
Diesel	Offroad	200	0.15625	0.69049	1.14582	0.00131	0.03946	0.03354	136.92000	0.00781	0.00344	138.15169
Diesel	Offroad	201	0.15703	0.69394	1.15155	0.00131	0.03965	0.03371	137.60460	0.00785	0.00346	138.84245
Diesel	Offroad	202	0.15781	0.69739	1.15728	0.00132	0.03985	0.03387	138.28920	0.00789	0.00348	139.53321
Diesel	Offroad	203	0.15859	0.70085	1.16301	0.00133	0.04005	0.03404	138.97380	0.00793	0.00350	140.22397
Diesel	Offroad	204	0.15937	0.70430	1.16873	0.00133	0.04025	0.03421	139.65840	0.00797	0.00351	140.91473
Diesel	Offroad	205	0.16015	0.70775	1.17446	0.00134	0.04044	0.03438	140.34300	0.00801	0.00353	141.60548
Diesel	Offroad	206	0.16094	0.71120	1.18019	0.00134	0.04064	0.03454	141.02760	0.00805	0.00355	142.29624
Diesel	Offroad	207	0.16172	0.71466	1.18592	0.00135	0.04084	0.03471	141.71220	0.00809	0.00356	142.98700
Diesel	Offroad	208	0.16250	0.71811	1.19165	0.00136	0.04103	0.03488	142.39680	0.00812	0.00358	143.67776
Diesel	Offroad	209	0.16328	0.72156	1.19738	0.00136	0.04123	0.03505	143.08140	0.00816	0.00360	144.36852
Diesel	Offroad	210	0.16406	0.72501	1.20311	0.00137	0.04143	0.03521	143.76600	0.00820	0.00362	145.05928
Diesel	Offroad	211	0.16484	0.72847	1.20884	0.00138	0.04163	0.03538	144.45060	0.00824	0.00363	145.75004
Diesel	Offroad	212	0.16562	0.73192	1.21457	0.00138	0.04182	0.03555	145.13520	0.00828	0.00365	146.44079
Diesel	Offroad	213	0.16640	0.73537	1.22030	0.00139	0.04202	0.03572	145.81980	0.00832	0.00367	147.13155
Diesel	Offroad	214	0.16719	0.73882	1.22603	0.00140	0.04222	0.03589	146.50440	0.00836	0.00369	147.82231
Diesel	Offroad	215	0.16797	0.74228	1.23175	0.00140	0.04242	0.03605	147.18900	0.00840	0.00370	148.51307
Diesel	Offroad	216	0.16875	0.74573	1.23748	0.00141	0.04261	0.03622	147.87360	0.00844	0.00372	149.20383
Diesel	Offroad	217	0.16953	0.74918	1.24321	0.00142	0.04281	0.03639	148.55820	0.00848	0.00374	149.89459
Diesel	Offroad	218	0.17031	0.75263	1.24894	0.00142	0.04301	0.03656	149.24280	0.00852	0.00375	150.58534
Diesel	Offroad	219	0.17109	0.75609	1.25467	0.00143	0.04320	0.03672	149.92740	0.00855	0.00377	151.27610
Diesel	Offroad	220	0.17187	0.75954	1.26040	0.00144	0.04340	0.03689	150.61200	0.00859	0.00379	151.96686
Diesel	Offroad	221	0.17265	0.76299	1.26613	0.00144	0.04360	0.03706	151.29660	0.00863	0.00381	152.65762
Diesel	Offroad	222	0.17344	0.76644	1.27186	0.00145	0.04380	0.03723	151.98120	0.00867	0.00382	153.34838
Diesel	Offroad	223	0.17422	0.76990	1.27759	0.00146	0.04399	0.03739	152.66580	0.00871	0.00384	154.03914
Diesel	Offroad	224	0.17500	0.77335	1.28332	0.00146	0.04419	0.03756	153.35040	0.00875	0.00386	154.72990
Diesel	Offroad	225	0.17578	0.77680	1.28905	0.00147	0.04439	0.03773	154.03500	0.00879	0.00387	155.42065
Diesel	Offroad	226	0.17656	0.78025	1.29477	0.00148	0.04459	0.03790	154.71960	0.00883	0.00389	156.11141
Diesel	Offroad	227	0.17734	0.78371	1.30050	0.00148	0.04478	0.03807	155.40420	0.00887	0.00391	156.80217
Diesel	Offroad	228	0.17812	0.78716	1.30623	0.00149	0.04498	0.03823	156.08880	0.00891	0.00393	157.49293
Diesel	Offroad	229	0.17890	0.79061	1.31196	0.00150	0.04518	0.03840	156.77340	0.00894	0.00394	158.18369
Diesel	Offroad	230	0.17969	0.79406	1.31769	0.00150	0.04538	0.03857	157.45800	0.00898	0.00396	158.87445
Diesel	Offroad	231	0.18047	0.79752	1.32342	0.00151	0.04557	0.03874	158.14260	0.00902	0.00398	159.56520
Diesel	Offroad	232	0.18125	0.80097	1.32915	0.00151	0.04577	0.03890	158.82720	0.00906	0.00400	160.25596
Diesel	Offroad	233	0.18203	0.80442	1.33488	0.00152	0.04597	0.03907	159.51180	0.00910	0.00401	160.94672
Diesel	Offroad	234	0.18281	0.80787	1.34061	0.00153	0.04616	0.03924	160.19640	0.00914	0.00403	161.63748
Diesel	Offroad	235	0.18359	0.81133	1.34634	0.00153	0.04636	0.03941	160.88100	0.00918	0.00405	162.32824
Diesel	Offroad	236	0.18437	0.81478	1.35207	0.00154	0.04656	0.03957	161.56560	0.00922	0.00406	163.01900
Diesel	Offroad	237	0.18515	0.81823	1.35779	0.00155	0.04676	0.03974	162.25020	0.00926	0.00408	163.70976
Diesel	Offroad	238	0.18593	0.82168	1.36352	0.00155	0.04695	0.03991	162.93480	0.00930	0.00410	164.40051
Diesel	Offroad	239	0.18672	0.82513	1.36925	0.00156	0.04715	0.04008	163.61940	0.00934	0.00412	165.09127
Diesel	Offroad	240	0.18750	0.82859	1.37498	0.00157	0.04735	0.04025	164.30400	0.00937	0.00413	165.78203
Diesel	Offroad	241	0.18828	0.83204	1.38071	0.00157	0.04755	0.04041	164.98860	0.00941	0.00415	166.47279
Diesel	Offroad	242	0.18906	0.83549	1.38644	0.00158	0.04774	0.04058	165.67320	0.00945	0.00417	167.16355
Diesel	Offroad	243	0.18984	0.83894	1.39217	0.00159	0.04794	0.04075	166.35780	0.00949	0.00418	167.85431
Diesel	Offroad	244	0.19062	0.84240	1.39790	0.00159	0.04814	0.04092	167.04240	0.00953	0.00420	168.54506
Diesel	Offroad	245	0.19140	0.84585	1.40363	0.00160	0.04833	0.04108	167.72700	0.00957	0.00422	169.23582
Diesel	Offroad	246	0.19218	0.84930	1.40936	0.00161	0.04853	0.04125	168.41160	0.00961	0.00424	169.92658
Diesel	Offroad	247	0.19297	0.85275	1.41509	0.00161	0.04873	0.04142	169.09620	0.00965	0.00425	170.61734
Diesel	Offroad	248	0.19375	0.85621	1.42081	0.00162	0.04893	0.04159	169.78080	0.00969	0.00427	171.30810
Diesel	Offroad	249	0.19453	0.85966	1.42654	0.00163	0.04912	0.04175	170.46540	0.00973	0.00429	171.99886
Diesel	Offroad	250	0.19531	0.86311	1.43227	0.00163	0.04932	0.04192	171.15000	0.00977	0.00431	172.68962
Diesel	Offroad	251	0.19609	0.86656	1.43800	0.00164	0.04952	0.04209	171.83460	0.00980	0.00432	173.38037
Diesel	Offroad	252	0.19687	0.87002	1.44373	0.00165	0.04972	0.04226	172.51920	0.00984	0.00434	174.07113
Diesel	Offroad	253	0.19765	0.87347	1.44946	0.00165	0.04991	0.04243	173.20380	0.00988	0.00436	174.76189
Diesel	Offroad	254	0.19843	0.87692	1.45519	0.00166	0.05011	0.04259	173.88840	0.00992	0.00437	175.45265
Diesel	Offroad	255	0.19922	0.88037	1.46092	0.00166	0.05031	0.04276	174.57300	0.00996	0.00439	176.14341
Diesel	Offroad	256	0.20000	0.88383	1.46665	0.00167	0.05050	0.04293	175.25760	0.01000	0.00441	176.83417
Diesel	Offroad	257	0.20078	0.88728	1.47238	0.00168	0.05070	0.04310	175.94220	0.01004	0.00443	177.52492
Diesel	Offroad	258	0.20156	0.89073	1.47811	0.00168	0.05090	0.04326	176.62680	0.01008	0.00444	178.21568
Diesel	Offroad	259	0.20234	0.89418	1.48383	0.00169	0.05110	0.04343	177.31140	0.01012	0.00446	178.90644
Diesel	Offroad	260	0.20312	0.89764	1.48956	0.00170	0.05129	0.04360	177.99600	0.01016	0.00448	179.59720
Diesel	Offroad	261	0.20390	0.90109	1.49529	0.00170	0.05149	0.04377	178.68060	0.01019	0.00449	180.28796
Diesel	Offroad	262	0.20468	0.90454	1.50102	0.00171	0.05169	0.04393	179.36520	0.01023	0.00451	180.97872

Factors

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
Diesel	Offroad	263	0.20547	0.90799	1.50675	0.00172	0.05189	0.04410	180.04980	0.01027	0.00453	181.66947
Diesel	Offroad	264	0.20625	0.91145	1.51248	0.00172	0.05208	0.04427	180.73440	0.01031	0.00455	182.36023
Diesel	Offroad	265	0.20703	0.91490	1.51821	0.00173	0.05228	0.04444	181.41900	0.01035	0.00456	183.05099
Diesel	Offroad	266	0.20781	0.91835	1.52394	0.00174	0.05248	0.04461	182.10360	0.01039	0.00458	183.74175
Diesel	Offroad	267	0.20859	0.92180	1.52967	0.00174	0.05267	0.04477	182.78820	0.01043	0.00460	184.43251
Diesel	Offroad	268	0.20937	0.92526	1.53540	0.00175	0.05287	0.04494	183.47280	0.01047	0.00461	185.12327
Diesel	Offroad	269	0.21015	0.92871	1.54113	0.00176	0.05307	0.04511	184.15740	0.01051	0.00463	185.81403
Diesel	Offroad	270	0.21093	0.93216	1.54685	0.00176	0.05327	0.04528	184.84200	0.01055	0.00465	186.50478
Diesel	Offroad	271	0.21172	0.93561	1.55258	0.00177	0.05346	0.04544	185.52660	0.01059	0.00467	187.19554
Diesel	Offroad	272	0.21250	0.93907	1.55831	0.00178	0.05366	0.04561	186.21120	0.01062	0.00468	187.88630
Diesel	Offroad	273	0.21328	0.94252	1.56404	0.00178	0.05386	0.04578	186.89580	0.01066	0.00470	188.57706
Diesel	Offroad	274	0.21406	0.94597	1.56977	0.00179	0.05406	0.04595	187.58040	0.01070	0.00472	189.26782
Diesel	Offroad	275	0.21484	0.94942	1.57550	0.00180	0.05425	0.04611	188.26500	0.01074	0.00474	189.95858
Diesel	Offroad	276	0.21562	0.95288	1.58123	0.00180	0.05445	0.04628	188.94960	0.01078	0.00475	190.64933
Diesel	Offroad	277	0.21640	0.95633	1.58696	0.00181	0.05465	0.04645	189.63420	0.01082	0.00477	191.34009
Diesel	Offroad	278	0.21718	0.95978	1.59269	0.00181	0.05484	0.04662	190.31880	0.01086	0.00479	192.03085
Diesel	Offroad	279	0.21797	0.96323	1.59842	0.00182	0.05504	0.04679	191.00340	0.01090	0.00480	192.72161
Diesel	Offroad	280	0.21875	0.96669	1.60415	0.00183	0.05524	0.04695	191.68800	0.01094	0.00482	193.41237
Diesel	Offroad	281	0.21953	0.97014	1.60987	0.00183	0.05544	0.04712	192.37260	0.01098	0.00484	194.10313
Diesel	Offroad	282	0.22031	0.97359	1.61560	0.00184	0.05563	0.04729	193.05720	0.01101	0.00486	194.79389
Diesel	Offroad	283	0.22109	0.97704	1.62133	0.00185	0.05583	0.04746	193.74180	0.01105	0.00487	195.48464
Diesel	Offroad	284	0.22187	0.98050	1.62706	0.00185	0.05603	0.04762	194.42640	0.01109	0.00489	196.17540
Diesel	Offroad	285	0.22265	0.98395	1.63279	0.00186	0.05623	0.04779	195.11100	0.01113	0.00491	196.86616
Diesel	Offroad	286	0.22343	0.98740	1.63852	0.00187	0.05642	0.04796	195.79560	0.01117	0.00492	197.55692
Diesel	Offroad	287	0.22422	0.99085	1.64425	0.00187	0.05662	0.04813	196.48020	0.01121	0.00494	198.24768
Diesel	Offroad	288	0.22500	0.99430	1.64998	0.00188	0.05682	0.04829	197.16480	0.01125	0.00496	198.93844
Diesel	Offroad	289	0.22578	0.99776	1.65571	0.00189	0.05701	0.04846	197.84940	0.01129	0.00498	199.62919
Diesel	Offroad	290	0.22656	1.00121	1.66144	0.00189	0.05721	0.04863	198.53400	0.01133	0.00499	200.31995
Diesel	Offroad	291	0.22734	1.00466	1.66717	0.00190	0.05741	0.04880	199.21860	0.01137	0.00501	201.01071
Diesel	Offroad	292	0.22812	1.00811	1.67289	0.00191	0.05761	0.04897	199.90320	0.01141	0.00503	201.70147
Diesel	Offroad	293	0.22890	1.01157	1.67862	0.00191	0.05780	0.04913	200.58780	0.01144	0.00505	202.39223
Diesel	Offroad	294	0.22968	1.01502	1.68435	0.00192	0.05800	0.04930	201.27240	0.01148	0.00506	203.08299
Diesel	Offroad	295	0.23047	1.01847	1.69008	0.00193	0.05820	0.04947	201.95700	0.01152	0.00508	203.77375
Diesel	Offroad	296	0.23125	1.02192	1.69581	0.00193	0.05840	0.04964	202.64160	0.01156	0.00510	204.46450
Diesel	Offroad	297	0.23203	1.02538	1.70154	0.00194	0.05859	0.04980	203.32620	0.01160	0.00511	205.15526
Diesel	Offroad	298	0.23281	1.02883	1.70727	0.00195	0.05879	0.04997	204.01080	0.01164	0.00513	205.84602
Diesel	Offroad	299	0.23359	1.03228	1.71300	0.00195	0.05899	0.05014	204.69540	0.01168	0.00515	206.53678
Diesel	**Offroad**	**300**	**0.22727**	**1.03573**	**1.66664**	**0.00196**	**0.05918**	**0.05031**	**205.38000**	**0.01172**	**0.00517**	**207.22754**
Diesel	Offroad	310	0.23485	1.07026	1.72220	0.00202	0.06116	0.05198	212.22600	0.01211	0.00534	214.13512
Diesel	Offroad	320	0.24242	1.10478	1.77775	0.00209	0.06313	0.05366	219.07200	0.01250	0.00551	221.04271
Diesel	Offroad	330	0.25000	1.13931	1.83331	0.00215	0.06510	0.05534	225.91800	0.01289	0.00568	227.95029
Diesel	Offroad	340	0.25757	1.17383	1.88886	0.00222	0.06708	0.05701	232.76400	0.01328	0.00585	234.85788
Diesel	Offroad	350	0.26515	1.20836	1.94442	0.00228	0.06905	0.05869	239.61000	0.01367	0.00603	241.76546
Diesel	Offroad	360	0.27272	1.24288	1.99997	0.00235	0.07102	0.06037	246.45600	0.01406	0.00620	248.67305
Diesel	Offroad	370	0.28030	1.27741	2.05553	0.00242	0.07299	0.06205	253.30200	0.01445	0.00637	255.58063
Diesel	Offroad	380	0.28787	1.31193	2.11108	0.00248	0.07497	0.06372	260.14800	0.01484	0.00654	262.48821
Diesel	Offroad	390	0.29545	1.34645	2.16664	0.00255	0.07694	0.06540	266.99400	0.01523	0.00672	269.39580
Diesel	Offroad	400	0.30303	1.38098	2.22219	0.00261	0.07891	0.06708	273.84000	0.01562	0.00689	276.30338
Diesel	Offroad	410	0.31060	1.41550	2.27775	0.00268	0.08089	0.06875	280.68600	0.01601	0.00706	283.21097
Diesel	Offroad	420	0.31818	1.45003	2.33330	0.00274	0.08286	0.07043	287.53200	0.01641	0.00723	290.11855
Diesel	Offroad	430	0.32575	1.48455	2.38886	0.00281	0.08483	0.07211	294.37800	0.01680	0.00740	297.02614
Diesel	Offroad	440	0.33333	1.51908	2.44441	0.00287	0.08680	0.07378	301.22400	0.01719	0.00758	303.93372
Diesel	Offroad	450	0.34090	1.55360	2.49997	0.00294	0.08878	0.07546	308.07000	0.01758	0.00775	310.84131
Diesel	Offroad	460	0.34848	1.58813	2.55552	0.00300	0.09075	0.07714	314.91600	0.01797	0.00792	317.74889
Diesel	Offroad	470	0.35606	1.62265	2.61108	0.00307	0.09272	0.07881	321.76200	0.01836	0.00809	324.65648
Diesel	Offroad	480	0.36363	1.65717	2.66663	0.00313	0.09470	0.08049	328.60800	0.01875	0.00827	331.56406
Diesel	Offroad	490	0.37121	1.69170	2.72219	0.00320	0.09667	0.08217	335.45400	0.01914	0.00844	338.47165
Diesel	Offroad	500	0.37878	1.72622	2.77774	0.00326	0.09864	0.08385	342.30000	0.01953	0.00861	345.37923
Diesel	Offroad	510	0.38636	1.76075	2.83330	0.00333	0.10061	0.08552	349.14600	0.01992	0.00878	352.28681
Diesel	Offroad	520	0.39393	1.79527	2.88885	0.00339	0.10259	0.08720	355.99200	0.02031	0.00895	359.19440
Diesel	Offroad	530	0.40151	1.82980	2.94440	0.00346	0.10456	0.08888	362.83800	0.02070	0.00913	366.10198
Diesel	Offroad	540	0.40909	1.86432	2.99996	0.00353	0.10653	0.09055	369.68400	0.02109	0.00930	373.00957
Diesel	Offroad	550	0.41666	1.89885	3.05551	0.00359	0.10851	0.09223	376.53000	0.02148	0.00947	379.91715
Diesel	Offroad	560	0.42424	1.93337	3.11107	0.00366	0.11048	0.09391	383.37600	0.02187	0.00964	386.82474
Diesel	Offroad	570	0.43181	1.96789	3.16662	0.00372	0.11245	0.09558	390.22200	0.02226	0.00982	393.73232
Diesel	Offroad	580	0.43939	2.00242	3.22218	0.00379	0.11442	0.09726	397.06800	0.02265	0.00999	400.63991
Diesel	Offroad	590	0.44696	2.03694	3.27773	0.00385	0.11640	0.09894	403.91400	0.02305	0.01016	407.54749
Diesel	**Offroad**	**600**	**0.45454**	**2.07147**	**3.33329**	**0.00392**	**0.11837**	**0.10061**	**410.76000**	**0.02344**	**0.01033**	**414.45508**
Diesel	Offroad	610	0.46211	2.10599	3.38884	0.00398	0.12034	0.10229	417.60600	0.02383	0.01050	421.36266
Diesel	Offroad	620	0.46969	2.14052	3.44440	0.00405	0.12232	0.10397	424.45200	0.02422	0.01068	428.27025
Diesel	Offroad	630	0.47727	2.17504	3.49995	0.00411	0.12429	0.10564	431.29800	0.02461	0.01085	435.17783
Diesel	Offroad	640	0.48484	2.20957	3.55551	0.00418	0.12626	0.10732	438.14400	0.02500	0.01102	442.08541
Diesel	Offroad	650	0.49242	2.24409	3.61106	0.00424	0.12823	0.10900	444.99000	0.02539	0.01119	448.99300
Diesel	Offroad	660	0.49999	2.27862	3.66662	0.00431	0.13021	0.11068	451.83600	0.02578	0.01137	455.90058
Diesel	Offroad	670	0.50757	2.31314	3.72217	0.00437	0.13218	0.11235	458.68200	0.02617	0.01154	462.80817
Diesel	Offroad	680	0.51514	2.34766	3.77773	0.00444	0.13415	0.11403	465.52800	0.02656	0.01171	469.71575
Diesel	Offroad	690	0.52272	2.38219	3.83328	0.00450	0.13613	0.11571	472.37400	0.02695	0.01188	476.62334
Diesel	Offroad	700	0.53030	2.41671	3.88884	0.00457	0.13810	0.11738	479.22000	0.02734	0.01205	483.53092

Factors

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
Diesel	Offroad	710	0.53787	2.45124	3.94439	0.00464	0.14007	0.11906	486.06600	0.02773	0.01223	490.43851
Diesel	Offroad	720	0.54545	2.48576	3.99995	0.00470	0.14204	0.12074	492.91200	0.02812	0.01240	497.34609
Diesel	Offroad	730	0.55302	2.52029	4.05550	0.00477	0.14402	0.12241	499.75800	0.02851	0.01257	504.25368
Diesel	Offroad	740	0.56060	2.55481	4.11106	0.00483	0.14599	0.12409	506.60400	0.02890	0.01274	511.16126
Diesel	**Offroad**	**750**	**0.56817**	**2.58934**	**4.16661**	**0.00490**	**0.14796**	**0.12577**	**513.45000**	**0.02930**	**0.01292**	**518.06885**
Diesel	Offroad	760	0.57575	2.62386	4.22217	0.00496	0.14993	0.12744	520.29600	0.02969	0.01309	524.97643
Diesel	Offroad	770	0.58333	2.65838	4.27772	0.00503	0.15191	0.12912	527.14200	0.03008	0.01326	531.88401
Diesel	Offroad	780	0.59090	2.69291	4.33327	0.00509	0.15388	0.13080	533.98800	0.03047	0.01343	538.79160
Diesel	Offroad	790	0.59848	2.72743	4.38883	0.00516	0.15585	0.13248	540.83400	0.03086	0.01360	545.69918
Diesel	Offroad	800	0.60605	2.76196	4.44438	0.00522	0.15783	0.13415	547.68000	0.03125	0.01378	552.60677
Diesel	Offroad	810	0.61363	2.79648	4.49994	0.00529	0.15980	0.13583	554.52600	0.03164	0.01395	559.51435
Diesel	Offroad	820	0.62120	2.83101	4.55549	0.00535	0.16177	0.13751	561.37200	0.03203	0.01412	566.42194
Diesel	Offroad	830	0.62878	2.86553	4.61105	0.00542	0.16374	0.13918	568.21800	0.03242	0.01429	573.32952
Diesel	Offroad	840	0.63636	2.90006	4.66660	0.00548	0.16572	0.14086	575.06400	0.03281	0.01446	580.23711
Diesel	Offroad	850	0.64393	2.93458	4.72216	0.00555	0.16769	0.14254	581.91000	0.03320	0.01464	587.14469
Diesel	Offroad	860	0.65151	2.96910	4.77771	0.00561	0.16966	0.14421	588.75600	0.03359	0.01481	594.05228
Diesel	Offroad	870	0.65908	3.00363	4.83327	0.00568	0.17164	0.14589	595.60200	0.03398	0.01498	600.95986
Diesel	Offroad	880	0.66666	3.03815	4.88882	0.00575	0.17361	0.14757	602.44800	0.03437	0.01515	607.86744
Diesel	Offroad	890	0.67423	3.07268	4.94438	0.00581	0.17558	0.14924	609.29400	0.03476	0.01533	614.77503
Diesel	Offroad	900	0.68181	3.10720	4.99993	0.00588	0.17755	0.15092	616.14000	0.03515	0.01550	621.68261
Diesel	Offroad	910	0.68938	3.14173	5.05549	0.00594	0.17953	0.15260	622.98600	0.03554	0.01567	628.59020
Diesel	Offroad	920	0.69696	3.17625	5.11104	0.00601	0.18150	0.15428	629.83200	0.03594	0.01584	635.49778
Diesel	Offroad	930	0.70454	3.21078	5.16660	0.00607	0.18347	0.15595	636.67800	0.03633	0.01601	642.40537
Diesel	Offroad	940	0.71211	3.24530	5.22215	0.00614	0.18545	0.15763	643.52400	0.03672	0.01619	649.31295
Diesel	Offroad	950	0.71969	3.27982	5.27771	0.00620	0.18742	0.15931	650.37000	0.03711	0.01636	656.22054
Diesel	Offroad	960	0.72726	3.31435	5.33326	0.00627	0.18939	0.16098	657.21600	0.03750	0.01653	663.12812
Diesel	Offroad	970	0.73484	3.34887	5.38882	0.00633	0.19136	0.16266	664.06200	0.03789	0.01670	670.03571
Diesel	Offroad	980	0.74241	3.38340	5.44437	0.00640	0.19334	0.16434	670.90800	0.03828	0.01688	676.94329
Diesel	Offroad	990	0.74999	3.41792	5.49993	0.00646	0.19531	0.16601	677.75400	0.03867	0.01705	683.85088
Diesel	Offroad	1000	0.75757	3.45245	5.55548	0.00653	0.19728	0.16769	684.60000	0.03906	0.01722	690.75846
Diesel	Offroad	1010	0.76514	3.48697	5.61104	0.00659	0.19926	0.16937	691.44600	0.03945	0.01739	697.66604
Diesel	Offroad	1020	0.77272	3.52150	5.66659	0.00666	0.20123	0.17104	698.29200	0.03984	0.01756	704.57363
Diesel	Offroad	1030	0.78029	3.55602	5.72215	0.00672	0.20320	0.17272	705.13800	0.04023	0.01774	711.48121
Diesel	Offroad	1040	0.78787	3.59055	5.77770	0.00679	0.20517	0.17440	711.98400	0.04062	0.01791	718.38880
Diesel	Offroad	1050	0.79544	3.62507	5.83325	0.00685	0.20715	0.17607	718.83000	0.04101	0.01808	725.29638
Diesel	Offroad	1060	0.80302	3.65959	5.88881	0.00692	0.20912	0.17775	725.67600	0.04140	0.01825	732.20397
Diesel	Offroad	1070	0.81060	3.69412	5.94436	0.00699	0.21109	0.17943	732.52200	0.04179	0.01843	739.11155
Diesel	Offroad	1080	0.81817	3.72864	5.99992	0.00705	0.21307	0.18111	739.36800	0.04218	0.01860	746.01914
Diesel	Offroad	1090	0.82575	3.76317	6.05547	0.00712	0.21504	0.18278	746.21400	0.04258	0.01877	752.92672
Diesel	Offroad	1100	0.83332	3.79769	6.11103	0.00718	0.21701	0.18446	753.06000	0.04297	0.01894	759.83431
Diesel	Offroad	1110	0.84090	3.83222	6.16658	0.00725	0.21898	0.18614	759.90600	0.04336	0.01911	766.74189
Diesel	Offroad	1120	0.84847	3.86674	6.22214	0.00731	0.22096	0.18781	766.75200	0.04375	0.01929	773.64948
Diesel	Offroad	1130	0.85605	3.90127	6.27769	0.00738	0.22293	0.18949	773.59800	0.04414	0.01946	780.55706
Diesel	Offroad	1140	0.86362	3.93579	6.33325	0.00744	0.22490	0.19117	780.44400	0.04453	0.01963	787.46464
Diesel	Offroad	1150	0.87120	3.97031	6.38880	0.00751	0.22688	0.19284	787.29000	0.04492	0.01980	794.37223
Diesel	Offroad	1160	0.87878	4.00484	6.44436	0.00757	0.22885	0.19452	794.13600	0.04531	0.01998	801.27981
Diesel	Offroad	1170	0.88635	4.03936	6.49991	0.00764	0.23082	0.19620	800.98200	0.04570	0.02015	808.18740
Diesel	Offroad	1180	0.89393	4.07389	6.55547	0.00770	0.23279	0.19787	807.82800	0.04609	0.02032	815.09498
Diesel	Offroad	1190	0.90150	4.10841	6.61102	0.00777	0.23477	0.19955	814.67400	0.04648	0.02049	822.00257
Diesel	Offroad	1200	0.90908	4.14294	6.66658	0.00783	0.23674	0.20123	821.52000	0.04687	0.02066	828.91015
Gasoline	**Onroad LD**	**LD**	**0.00070**	**0.00660**	**0.00065**	**0.00001**	**0.00009**	**0.00006**	**1.10257**	**0.00006**	**0.00003**	**1.11182**
Diesel	Onroad MD	MD	0.00190	0.01284	0.01425	0.00003	0.00055	0.00046	2.79845	0.00009	0.00014	2.84273
Diesel	Onroad HD	HD	0.00202	0.00846	0.02418	0.00004	0.00118	0.00101	4.21279	0.00009	0.00009	4.24176
Zero	None	0.0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
Zero	Electric	0.0	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

VLOOKUP Sort	Fuel List	Load Factor
2-stroke	50:1 gas/oil mix	50%
Electric	Zero	
Methane	CNG	60%
None	Zero	
Offroad	Diesel	60%
Onroad HD	Diesel	
Onroad LD	Gasoline	
Onroad MD	Diesel	
Propane	LPG	60%
Sport	Gasoline	30%
Turbine	Jet A	90%
Utility	Gasoline	50%

Factors

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
40 CFR 89.112	Range	Range	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Table 1	KW	BHP	g/kw-hr	g/kw-hr	g/kw-hr		g/kw-hr					
Tier 2 (2005-07)	<8	<11	0.90	8.0	6.60	—	0.80	—	—	—	—	—
Tier 2 (2005-07)	8-19	11-25	0.90	6.6	6.60	—	0.80	—	—	—	—	—
Tier 2 (2004-07)	19-37	25-50	0.90	5.5	6.60	—	0.60	—	—	—	—	—
Tier 2 (2004-07)	37-56	50-75	0.90	5.0	6.60	—	0.40	—	—	—	—	—
Tier 2 (2004-07)	56-75	75-101	0.90	5.0	6.60	—	0.40	—	—	—	—	—
Tier 2 (2003-06)	75-130	101-174	0.79	5.0	5.81	—	0.30	—	—	—	—	—
Tier 2 (2003-05)	130-225	174-302	0.79	3.5	5.81	—	0.20	—	—	—	—	—
Tier 2 (2001-05)	225-450	302-603	0.77	3.5	5.63	—	0.20	—	—	—	—	—
Tier 2 (2002-05)	450-560	603-751	0.77	3.5	5.63	—	0.20	—	—	—	—	—
Tier 2 (2006-10)	560-900	751-1207	0.77	3.5	5.63	—	0.20	—	—	—	—	—

Engine	Heat Rate	Range	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Category	BTU/BHP-hr	BHP	lb/bhp-hr	lb/bhp-hr	lb/bhp-hr	lb/bhp-hr	lb/bhp-hr	lb/bhp-hr	lb/bhp-hr	lb/bhp-hr	lb/bhp-hr	lb/bhp-hr
Offroad	8,000	5-9.9 (0.1)	8.88E-04	7.89E-03	6.51E-03	7.46E-06	7.89E-04	6.71E-04	7.82E-01	4.46E-05	1.97E-05	7.89E-01
Offroad	8,000	10-24 (1)	8.88E-04	6.51E-03	6.51E-03	7.46E-06	7.89E-04	6.71E-04	7.82E-01	4.46E-05	1.97E-05	7.89E-01
Offroad	7,000	25-49 (1)	8.88E-04	5.43E-03	6.51E-03	6.53E-06	5.92E-04	5.03E-04	6.85E-01	3.91E-05	1.72E-05	6.91E-01
Offroad	7,000	50-74 (1)	8.88E-04	4.93E-03	6.51E-03	6.53E-06	3.95E-04	3.35E-04	6.85E-01	3.91E-05	1.72E-05	6.91E-01
Offroad	7,000	75-99 (1)	8.88E-04	4.93E-03	6.51E-03	6.53E-06	3.95E-04	3.35E-04	6.85E-01	3.91E-05	1.72E-05	6.91E-01
Offroad	7,000	100-174 (1)	7.81E-04	4.93E-03	5.73E-03	6.53E-06	2.96E-04	2.52E-04	6.85E-01	3.91E-05	1.72E-05	6.91E-01
Offroad	7,000	175-299 (1)	7.81E-04	3.45E-03	5.73E-03	6.53E-06	1.97E-04	1.68E-04	6.85E-01	3.91E-05	1.72E-05	6.91E-01
Offroad	7,000	300-590 (10)	7.58E-04	3.45E-03	5.56E-03	6.53E-06	1.97E-04	1.68E-04	6.85E-01	3.91E-05	1.72E-05	6.91E-01
Offroad	7,000	600-740 (10)	7.58E-04	3.45E-03	5.56E-03	6.53E-06	1.97E-04	1.68E-04	6.85E-01	3.91E-05	1.72E-05	6.91E-01
Offroad	7,000	750-1200 (1(	7.58E-04	3.45E-03	5.56E-03	6.53E-06	1.97E-04	1.68E-04	6.85E-01	3.91E-05	1.72E-05	6.91E-01

Engine	Heat Rate	Range	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Category	BTU/BHP-hr	BHP	lb/bhp-hr	lb/bhp-hr	lb/bhp-hr	lb/bhp-hr	lb/bhp-hr	lb/bhp-hr	lb/bhp-hr	lb/bhp-hr	lb/bhp-hr	lb/bhp-hr
2-stroke A (2005)	14,000	0.1-0.9 (0.1)	3.70E-02	6.62E-01	4.11E-03	5.95E-04	7.83E-03	5.09E-03	1.10E+00	6.23E-05	2.73E-05	1.11E+00
2-stroke B (2005)	13,000	1.0-2.9 (0.1)	3.70E-02	6.62E-01	4.11E-03	5.95E-04	7.83E-03	5.09E-03	1.02E+00	5.79E-05	2.54E-05	1.03E+00
2-stroke C (2007)	12,000	3.0-9.9 (0.1)	5.33E-02	4.96E-01	5.92E-03	5.95E-04	7.83E-03	5.09E-03	9.44E-01	5.34E-05	2.34E-05	9.52E-01
2-stroke D (2007)	10,000	10-200 (1)	5.33E-02	4.96E-01	5.92E-03	5.95E-04	7.83E-03	5.09E-03	7.87E-01	4.45E-05	1.95E-05	7.93E-01
Methane	10,000	10-200 (1)	7.94E-03	3.34E-03	5.08E-03	3.60E-06	6.00E-05	3.90E-05	7.00E-01	1.38E-05	1.20E-06	7.00E-01
Propane	10,000	10-200 (1)	7.94E-03	3.34E-03	5.08E-03	3.60E-06	6.00E-05	3.90E-05	8.23E-01	6.00E-07	1.80E-06	8.24E-01
Sport	10,000	10-500 (1,10	5.67E-03	1.88E-01	4.89E-03	2.52E-04	3.00E-04	1.95E-04	4.72E-01	2.67E-05	1.17E-05	4.76E-01
Turbine	9,000	200-1000 (1(	3.24E-06	2.61E-05	6.95E-03	1.23E-05	9.47E-05	6.16E-05	1.29E+00	3.56E-05	4.13E-05	1.30E+00
Utility A (2003)	12,000	1.0-2.9 (0.1)	6.57E-03	5.01E-01	5.60E-03	4.30E-04	4.85E-04	3.15E-04	9.44E-01	5.34E-05	2.34E-05	9.52E-01
Utility B (2005)	11,000	3.0-9.9 (0.1)	5.02E-03	5.01E-01	4.27E-03	4.30E-04	4.85E-04	3.15E-04	8.65E-01	4.90E-05	2.15E-05	8.73E-01
Utility C	10,000	10-200 (1)	9.45E-03	3.14E-01	8.15E-03	4.20E-04	5.00E-04	3.25E-04	7.87E-01	4.45E-05	1.95E-05	7.93E-01

Engine/Motor Type		Output	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Fuel	Category	BHP	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit	lbs/unit
Engine	Model	Range	VOC	CO	NO_X	SO_X	PM_{10}	$PM_{2.5}$	CO_2	CH_4	N_20	CO_2 eqv
Category	Year	BHP	lb/mile	lb/mile	lb/mile	lb/mile	lb/mile	lb/mile	lb/mile	lb/mile	lb/mile	lb/mile
Onroad	2014	LD	0.00070	0.00660	0.00065	0.00001	0.00009	0.00006	1.10257	0.00006	0.00003	1.11182
Onroad	2014	MD	0.00190	0.01284	0.01425	0.00003	0.00055	0.00046	2.79845	0.00009	0.00014	2.84273
Onroad	2014	HD	0.00202	0.00846	0.02418	0.00004	0.00118	0.00101	4.21279	0.00009	0.00009	4.24176

GHG Reference	Annex 2	Annex 3	Annex 3	AP-42/Ax2	Annex 2	Annex 3	Annex 3	Composite
Property	Carbon	CH_4	N_2O	HHV	CO_2	CH_4	N_2O	CO_2e
Units	kg/mmBTU	g/kg fuel	g/kg fuel	BTU/lb	lb/mmBTU	lb/mmBTU	lb/mmBTU	lb/mmBTU
Diesel #2	20.17	0.18	0.08	19300	163.0	0.0093	0.0041	164.47
Gasoline	19.46	0.18	0.08	20300	157.3	0.0089	0.0039	158.70
Jet A	19.70	0.087	0.10	19800	159.2	0.0044	0.0051	160.87
CNG/LNG	14.42	0.052	0.004	22400	116.6	0.0023	0.0002	116.71
LPG	16.97	0.003	0.006	21600	137.2	0.0001	0.0003	137.30

Onroad Notes:
Onroad CARB/SCAQMD emission factors for 2014
Onroad N_2O per Annex 3, Table A-101
Onroad HD includes tire & brake wear
Units are lb/mile

Offroad Notes:
Offroad diesel is Tier 2 per 40 CFR 89.112; AP-42 Table 3.3-1
Offroad gasoline (2-stroke, sport, utility) per 40 CFR 90.103; AP-42 Table 3.3-1; Hare & Springer; Nonroad Sudy Report
Offroad gaseous fuels (methane, propane) per AP-42 Table 3.2-2
Offroad CO_2 per Annex 2, Table A-43
Offroad CH_4 & N_2O per Annex 3, Table A-103
Offroad diesel exhaust $PM_{2.5}$ = 85% of PM_{10} per EMFAC 2007 version 2.3
Offroad gasoline exhaust $PM_{2.5}$ = 65% of PM_{10} per EMFAC 2007 version 2.3
Units are lb/hr

Aviation Notes:
Aviation per AP-42 Tables 3.1-1, -2a adjusted for Jet A fuel HHV
Aviation CO_2 per Annex 2, Table A-43
Aviation CH_4 & N_2O per Annex 3, Table A-103
Aviation exhaust $PM_{2.5}$ = 65% of PM_{10} (assumed for Jet A)
Units are lb/hr

General Notes:
CNG = compressed/cryrogenic natural gas
LPG = liquified petroleum/propane gas
EPA GWPs for CO_2 eqv (1, 21, 310)

Other Counties

Attainment Status - North Central Coast Air Basin (2006-08 data)		
Criteria Pollutants	**Federal Standards**	**State Standards**
	Status	**Status**
Ozone (O_3)	Unclassified/Attainment	Moderate Nonattainment
Carbon Monoxide (CO)	Unclassified/Attainment	Unclassified/Attainment
Nitrogen Dioxide (NO_2)	Unclassified/Attainment	Attainment
Sulfur Dioxide (SO_2)	Unclassified	Attainment
Respirable Particulates (PM_{10})	Unclassified	Nonattainment
Fine Particulates ($PM_{2.5}$)	Unclassified/Attainment	Attainment
Lead (Pb)	Unclassified/Attainment	Attainment

Source: MBUAPCD 2009, CARB 2012b

Notes:

North Central Coast Air Basin (NCCAB) - Santa Cruz, San Benito, and Monterey Counties

Santa Cruz and Monterey Counties are "moderate" nonattainment for state 1-hour ozone standard

Santa Cruz and San Benito Counties are unclassified for CO; Monterey County is attainment for CO

Effective July 26, 2007, the ARB designated the NCCAB a nonattainment area for the State ozone standard, which was revised in 2006 to include an 8-hour standard of 0.070 ppm.

On March 12, 2008, EPA adopted a new 8-hour ozone standard of 0.075 ppm, while temporarily retaining the existing 8-hour standard of 0.08 ppm. EPA is expected to issue new designations by March 2010.

In 2006, the Federal 24-hour standard for $PM_{2.5}$ was revised from 65 to 35 ug/m^3. Although final designations have yet to be made, it is expected that the NCCAB will remain designated unclassified/attainment.

On October 15, 2008 EPA substantially strengthened the national ambient air quality standard for lead by lowering the level of the primary standard from 1.5 ug/m^3 to 0.15 ug/m^3. Initial recommendations for designations are to be made by October 2009 with final designations by January 2012.

Emissions Significance Thresholds - North Central Coast Air Basin		
Criteria Emissions	**Significance Thresholds**	
	Pounds per Day	**Tons per Year**
Volatile Organic Compounds (VOC as CH_4)	137	25
Carbon Monoxide (CO)	550	100
Oxides of Nitrogen (NO_X as NO_2)	137	25
Sulfur Dioxide (SO_X as SO_2)	150	27
Respirable Particulates (PM_{10})	82	15
Fine Particulates ($PM_{2.5}$)	--	--
Lead (Pb)	--	0.6

Sources: MBUAPCD 2008, 40 CFR 51.166(b)(23)(i)

Notes:

MBUAPCD thresholds expressed in pounds per day only; applies to construction

-- No applicable threshold

Federal Prevention of Significant Deterioration (PSD) thresholds apply for CO and lead

For comparison, VOC, NO_X, SO_X, and PM_{10}, equivalent tons per year is calculated from pounds per day

For ozone nonattainment areas, thresholds apply to precursors VOC and NO_X

Other Counties

Attainment Status - Northern Sonoma County		
Criteria Emissions	**Federal Standards**	**State Standards**
	Status	**Status**
Ozone (O_3)	Unclassified/Attainment	Uncharacterized/Transitional
Carbon Monoxide (CO)	Unclassified/Attainment	Unclassified
Oxides of Nitrogen (NO_X as NO_2)	Unclassified/Attainment	Attainment
Sulfur Dioxide (SO_X as SO_2)	Unclassified	Attainment
Respirable Particulates (PM_{10})	Unclassified	Attainment
Fine Particulates ($PM_{2.5}$)	Unclassified/Attainment	Unclassified
Lead (Pb)	Attainment	Attainment
Source: CARB 2012b		
Notes:		
Northern Sonoma County is transitional (uncharacterized) attainment for ozone		

Emissions Significance Thresholds - Northern Sonoma County	
Criteria Emissions	**Significance Threshold**
	Tons per Year
Volatile Organic Compounds (VOC as CH_4)	40
Carbon Monoxide (CO)	100
Oxides of Nitrogen (NO_X as NO_2)	40
Sulfur Dioxide (SO_X as SO_2)	40
Respirable Particulates (PM_{10})	15
Fine Particulates ($PM_{2.5}$)	10
Lead (Pb)	0.6
Source: 40 CFR 51.166(b)(23)(i)	

Integrated Vector
Management Program

APPENDIX D

NOISE TECHNICAL REPORT

Noise Technical Report

Project Name: Integrated Mosquito and Vector Management Programs for Nine Districts

Date: June 2013

Prepared for:

Alameda County Mosquito Abatement District
Alameda County Vector Control Services District
Contra Costa Mosquito and Vector Control District
Marin/Sonoma Mosquito and Vector Control District
Napa County Mosquito Abatement District
Northern Salinas Valley Mosquito Abatement District
San Mateo County Mosquito and Vector Control District
Santa Clara County Vector Control District
Solano County Mosquito Abatement District

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Acronyms

°C	degrees Celsius
°F	degrees Fahrenheit
AB	Assembly Bill
ACMAD	Alameda County Mosquito Abatement District
ACVCSD	Alameda County Vector Control Services District
ADT	average daily trips
ANSI	American National Standards Institute
Caltrans	California Department of Transportation
CCMVCD	Contra Costa Mosquito and Vector Control District
CCR	California Code of Regulations
CDFG	California Department of Fish and Game
CDPH	California Department of Public Health
CDPR	California Department of Pesticide Regulation
CEQA	California Environmental Quality Act
CFR	Code of Federal Regulations
CNEL	Community Noise Equivalent Level
dB	decibel
dBA	decibels, A-weighted scale
District	California Department of Food and Agriculture
DNL	day-night noise level (also Ldn)
DoD	U.S. Department of Defense
DOT	U.S. Department of Transportation
FHWA	Federal Highway Administration
HT	heavy trucks
Hz	Hertz
kHz	kiloHertz
L10-90	percentile sound levels (L1.7, L8.3, L10, L50, and L90)
Ldn	day-night equivalent noise level (also DNL)
Leq	time-averaged integrated equivalent noise level
Lmax	maximum sound level
Lmin	minimum sound level
LOR	local ordinances and regulations
Lp	sound pressure level (also SPL)
LT	light trucks or long-term

Lw	sound power level
MSMVCD	Marin/Sonoma Mosquito Vector Control District
MVC	mosquito and vector control
NCMAD	Napa County Mosquito Abatement District
NSVMAD	Northern Salinas Valley Mosquito Abatement District
PK15	Peak Noise Level
SCCVCD	Santa Clara County Vector Control District
SCMAD	Solano County Mosquito and Vector Control District
SEL	single event level
SMCMVCD	San Mateo County Mosquito and Vector Control District
SP7	SoundPLAN™ Version 7
SPL	sound pressure level (also Lp)
TNM	Traffic Noise Model
USEPA	U.S. Environmental Protection Agency

1 Introduction

This report provides technical information regarding the physical properties of noise; federal, state, and local noise regulations; noise generated by equipment and vehicles that would be used in each of the alternatives being considered in the Integrated Mosquito and Vector Management Programs Programmatic Environmental Impact Report, as well as Best Management Practices that would be implemented. The Integrated Mosquito and Vector Management Programs (Programs) would be implemented by nine mosquito abatement and/or vector control districts in northern California. The nine districts are: Alameda County Mosquito Abatement District (ACMAD), Alameda County Vector Control Services District (ACVCSD), Contra Costa Mosquito and Vector Control District (CCMVCD), Marin/Sonoma Mosquito and Vector Control District (MSMVCD), Napa County Mosquito Abatement District (NCMAD), Northern Salinas Valley Mosquito Abatement District (NSVMAD), San Mateo County Mosquito and Vector Control District (SMCMVCD), Santa Clara County Vector Control District (SCCVCD), and the Solano County Mosquito Abatement District (SCMAD).The Programs provide for mosquito and/or vector control activities within each District's Program Area. The nine District Program Areas include both the areas within the Districts and the surrounding counties where the Districts may provide mosquito and/or other vector management services when requested.

The immediate nine District Service Areas are located in the following nine counties of the state: Alameda, Contra Costa, Marin, Monterey, Napa, San Mateo, Santa Clara, Solano, and Sonoma. Control activities may also be provided in areas adjacent to the District Service Areas upon request of the adjacent jurisdictions to protect the health and safety of residents in adjacent jurisdictions. Actions that would be taken outside of the nine Districts' Service Areas are the same types of actions undertaken within the Districts' Service Areas and in similar types of habitats or sites. Therefore, the nine District Program Areas addressed in this report also include the ten surrounding counties: Mendocino, Merced, Lake, Sacramento, San Benito, San Francisco, San Joaquin, Santa Cruz, Solano, Stanislaus, Yolo, and the portion of Monterey County south of the NSVMAD.

1.1 Report Organization

This report discusses potential noise sources and regulatory requirements that may be applicable to Program implementation by the individual Districts. Following this Introduction (Section 1), are the following:

> Fundamentals of sound including equipment noise sources (Section 2)

> Noise criteria including regulatory standards and local noise ordinances (Section 3)

> Noise generated by District equipment (Section 4)

> Best management practices to reduce unwanted noise (Section 5)

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2 Fundamentals of Sound

Perceptible acoustical sensations can be generally classified into two broad categories: sound and vibration.

2.1 Sound and Noise

Sound is a disturbance in an elastic medium resulting in an audible sensation. Sound is also defined as mechanical energy transmitted from a vibrating or flowing source by longitudinal (or compression) waves through a compressible medium such as air. The term “noise” is both qualitative and quantitative, and is typically referred to as "unwanted” sound.

2.1.1 Vibration

Vibration is a disturbance in a solid elastic medium, which may produce a detectable motion. This differentiation between sound and vibration is most relevant for environmental noise studies when industrial or construction noise sources produce high energy waves at low frequencies that are below human audible thresholds but match the frequency response of nearby structures. These frequencies are typically less than 31 Hertz (Hz). This energy causes vibrations similar to earthquakes. Sources with audible components in addition to the vibration-producing low-frequency energy are typically heard after initial vibrations start and sometimes end depending on distance from the source.

2.2 Physiological and Physical Parameters

Sound can be further characterized by both physiological and physical parameters. These parameters include the following:

> Loudness, as a subjective or perceived noise level that is a qualitative physiological sensation

> Loudness as a numerical scale, using “A-weighted” decibels and by sones (units of perceived loudness)

> Annoyance from high-energy low-frequency single events. This events have well-documented annoyance factors on nearby human receptors. The percentage of annoyed listeners is dependent on the following conditions (U.S. Army 2005):

- Intensity
- Duration
- Repetition
- Abruptness of onset or cessation
- Background or ambient noise levels
- Interference with activity
- Previous experiences within the community
- Time of day
- Fear of personal danger from the noise sources
- Socioeconomic status and education level of the community
- The extent people believe that the noise could be controlled

> Sound intensity, the average flow of sound energy through a unit area in a sound field. Sound intensity is a vector quantity with both magnitude and direction.

> Frequency spectrum - the rate of oscillation in cycles per second.

> Wavelength, the distance between successive wave compressions and expansions.

> Energy content as sound pressure level, L_p (also written as SPL). The ear responds to sound pressure as sound waves represent oscillations of pressure just below atmospheric pressure (expansion of longitudinal wave) and just above atmospheric pressure (compression). These pressure oscillations cause the inner ear to vibrate. Sound level meters are also sensitive to these oscillations.

In particular, the SPL has become the most common descriptor used to characterize the loudness of an ambient or environmental sound level. Noise ordinances typically express SPL as “noise level” in dBA at a particular distance. Sound pressure is affected by geophysical properties such as air temperature, pressure, humidity, rain or snow, and wind, as well as physical barriers such as terrain, and the walls of structures. Sound energy dissipates with increasing distance from the source due to absorptive surfaces such as grass, trees, and water. Due to these factors, the noise level perceived by a receptor at a certain location depends on the following parameters:

> Distance between the noise source and the receptor

> Presence or absence of absorptive surfaces

> The amount of mitigative noise features between the receptor and noise source, including intervening terrain, structures, foliage, and ground cover

> Cumulative noise impacts from reflective surfaces, such as building facades, concrete, asphalt, water bodies, etc.

> Current weather conditions (snow, wind, rain) and weather-related ground cover (snow, mud, wet or dry ground)

2.3 Physical Properties of Sound

Sound levels are affected by distance from the source to receiver (propagation) and by localized atmospheric conditions. These are further described below.

2.3.1 Sound Propagation

In an ideal atmosphere without wind, temperature gradients, humidity or ground effects sound levels decay as 6 dB per doubling of distance from a stationary source due to geometrical spreading. If a source generates a level of 90 dBA at 50 feet, then geometrical spreading implies a level of 70 dBA at a distance of 500 feet from the source. If the source is moving, then the maximum level will obey the same relationship, but the exposure time is also a function of sideline distance. For a moving source, the time averaged integrated level (Leq) will decay as 3 dB per doubling of sideline distance (cylindrical spreading), providing the integration time is the constant and extends until the sound level has decayed to 10 dB below its peak level. In this case, if a source generates a Leq of 70 dBA during a drive by in which the source passes 50 feet from the observer at its closest point, then the Leq at 500 feet will be 60 dBA. These simple scaling laws are modified in reality by local atmospheric propagation effects. At low wind speeds and at distances of less than 100 feet, atmospheric propagation effects are small and can be ignored. At larger distances, atmospheric propagation will modify the decay of the sound level with distance. In addition, ground effects can be important at small distances from the source and will depend on the ground cover and the height of the source and receiver above the ground.

Figure 2-1 provides a range of noise levels in the ideal atmosphere at increasing sound power levels. Sound Power is the sound level generated at the noise source. Additionally, color shading delineates the

threshold of pain (purple), noise levels that would typically exceed regulatory thresholds (red), and noise levels that may exceed regulatory thresholds depending on time of day and time-weighting (yellow). Noise levels within the white and green bands are typically within or below regulatory thresholds.

Sound Power Level (L_w) of Noise Source (dB*)	Distance from Noise Source to Outdoor Receiver (Feet)											
	1	2	4	8	16	32	64	125	250	500	1000	2000
	Sound Pressure Level (Lp)											
150	144	138	132	126	120	114	108	102	96	90	84	78
140	134	128	122	116	110	104	98	92	86	80	74	68
130	124	118	112	106	100	94	88	82	76	70	64	58
120	114	108	102	96	90	84	78	72	66	60	54	48
110	104	98	92	86	80	74	68	62	56	50	44	38
108	102	96	90	84	78	72	66	60	54	48	42	36
106	100	94	88	82	76	70	64	58	52	46	40	34
104	98	92	86	80	74	68	62	56	50	44	38	32
102	96	90	84	78	72	66	60	54	48	42	36	30
100	94	88	82	76	70	64	58	52	46	40	34	28
98	92	86	80	74	68	62	56	50	44	38	32	26
96	90	84	78	72	66	60	54	48	42	36	30	24
94	88	82	76	70	64	58	52	46	40	34	28	22
93	87	81	75	69	63	57	51	45	39	33	27	21
92	86	80	74	68	62	56	50	44	38	32	26	20
91	85	79	73	67	61	55	49	43	37	31	25	19
90	84	78	72	66	60	54	48	42	36	30	24	18
89	83	77	71	65	59	53	47	41	35	29	23	17
88	82	76	70	64	58	52	46	40	34	28	22	16
87	81	75	69	63	57	51	45	39	33	27	21	15
86	80	74	68	62	56	50	44	38	32	26	20	14
85	79	73	67	61	55	49	43	37	31	25	19	13
84	78	72	66	60	54	48	42	36	30	24	18	12
83	77	71	65	59	53	47	41	35	29	23	17	11
82	76	70	64	58	52	46	40	34	28	22	16	10
81	75	69	63	57	51	45	39	33	27	21	15	9
80	74	68	62	56	50	44	38	32	26	20	14	8
79	73	67	61	55	49	43	37	31	25	19	13	7
78	72	66	60	54	48	42	36	30	24	18	12	6
77	71	65	59	53	47	41	35	29	23	17	11	5
76	70	64	58	52	46	40	34	28	22	16	10	4
75	69	63	57	51	45	39	33	27	21	15	9	3
74	68	62	56	50	44	38	32	26	20	14	8	2
73	67	61	55	49	43	37	31	25	19	13	7	1
72	66	60	54	48	42	36	30	24	18	12	6	0
71	65	59	53	47	41	35	29	23	17	11	5	
70	64	58	52	46	40	34	28	22	16	10	4	
69	63	57	51	45	39	33	27	21	15	9	3	
68	62	56	50	44	38	32	26	20	14	8	2	
67	61	55	49	43	37	31	25	19	13	7	1	
66	60	54	48	42	36	30	24	18	12	6	0	
65	59	53	47	41	35	29	23	17	11	5		
64	58	52	46	40	34	28	22	16	10	4		
63	57	51	45	39	33	27	21	15	9	3		
62	56	50	44	38	32	26	20	14	8	2		
61	55	49	43	37	31	25	19	13	7	1		
60	54	48	42	36	30	24	18	12	6	0		

Figure 2-1 Noise Level Attenuation Due to Geometric Spreading in an Ideal Atmosphere

2.3.2 Effects of Local Atmospheric Conditions

During periods of strong sunshine, the ground surface temperature is increased, and this causes heating of the lower atmosphere. These conditions cause the air temperature to decrease with height, which is referred to as a temperature lapse. When a temperature lapse exists, sound rays are refracted upwards, and a shadow zone is formed a few hundred feet from the source (Glegg 2005). In contrast, during the nighttime hours there is significant cooling of the ground, and the atmospheric temperature increases with height, causing a temperature inversion. This causes sound to be trapped in the lower atmosphere, and sound levels can exceed those expected from spherical spreading. Furthermore, focusing effects can occur from temperature inversions and higher sound levels may be observed in a local area at relatively large distances from the source (Hubbard 1995).

Wind gradients close to the ground can cause the same effects as temperature gradients. Sound propagating upwind is refracted upwards and forms a shadow zone. Sound propagating downwind is refracted downwards and is louder than expected (Hubbard 1995). Sound is also attenuated by molecular absorption as it propagates. This is a strong function of humidity, and frequency and standard curves are available to make corrections for atmospheric absorption of this type. Typically excess attenuations of 5 dB per 1,000 feet of propagation can be expected at 2 kiloHertz (kHz) for a relative humidity of 50-90 percent and temperatures over 60 degrees Fahrenheit (˚F) (Beranek 1971).

An example of excess attenuation over a lake in Europe shows an additional 2-5 dB of attenuation per kilometer over and above atmospheric absorption. Sound level measurements from this study also show that a shadow zone can be formed by a temperature lapse. At a distance of 650 feet in the downwind direction sound levels exceed expected values at 250 Hz by 1 dB, but in the upwind direction the levels are 10 dB lower than expected (Beranek 1971).

2.3.3 Ground Effects

When a source and/or receiver are placed aboveground an interference effect takes place that modifies the measured sound level. At very low frequencies, the spectral levels are increased by 6 dB (at all distances) and at higher frequencies a series of interference dips occur where the spectral level is reduced to zero. When the source and receiver are 4 feet above ground and separated by 50 feet over a hard surface, the first interference dip occurs at 439 Hz. At a source and receiver separation of 300 feet the first separation dip occurs at 2,636 Hz. The ground effect increases the dBA level by 3 dB over a free field level (i.e., the level that would occur if the ground were not present) for a broadband source when the interference dip is at a frequency of approximately 1,000 Hz or less. When the frequency of the first ground interference dip exceeds 20 kHz, then the dBA level is increased by 6 dB relative to the free field level. For propagation over hard surfaces the ground effect, therefore, reduces the geometrical spreading loss of the dBA level when the source and receiver are less than 2,400 feet apart. This effect is relatively small unless propagation takes place over soft ground cover, in which case the effect of ground absorption can be significant. Figure 2-2 illustrates the shadow zone created by a downwind noise source (upper portion), and also illustrates the focusing phenomena created by temperature inversion, upwind noise source, and ground/water surfaces (lower portion).

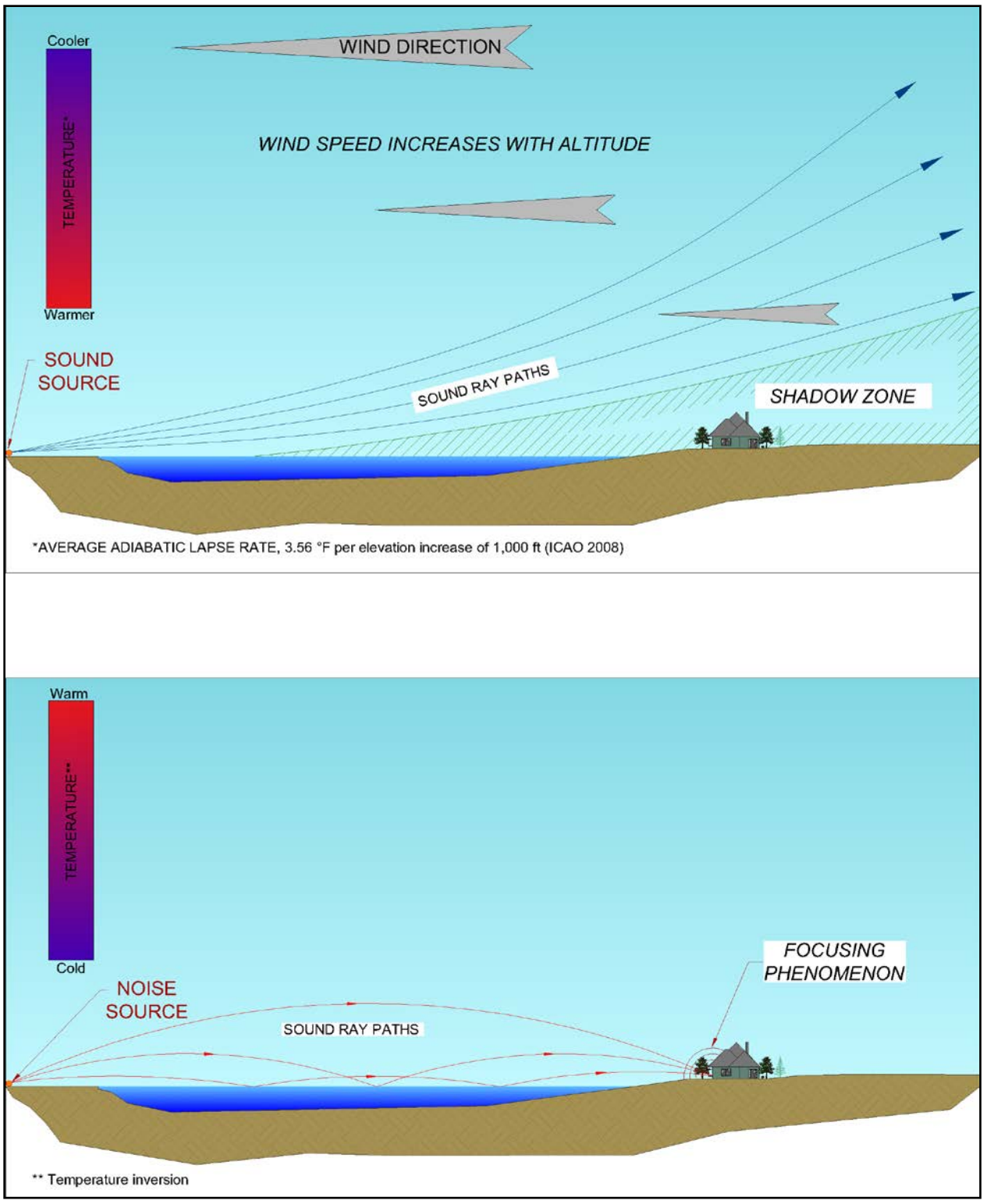

Figure 2-2 Ground Effect and Wind and Temperature Inversion

2.3.4 Reflection, Refraction, Absorption, and Transmission Losses

The sound level measured at a specific location at a discrete time is the sum of all noise source SPLs that converge at that point. Sound will refract around hard edges, be absorbed by foliage, structural materials, and the various atmospheric conditions previously described. Reflection will occur at hard surfaces where sound is not completely absorbed and/or scattered. Sound that reflects back to a source is called an echo. Transmission loss through structural materials such as walls and windows reduce sound pressure the most. Figure 2-3 illustrates these concepts.

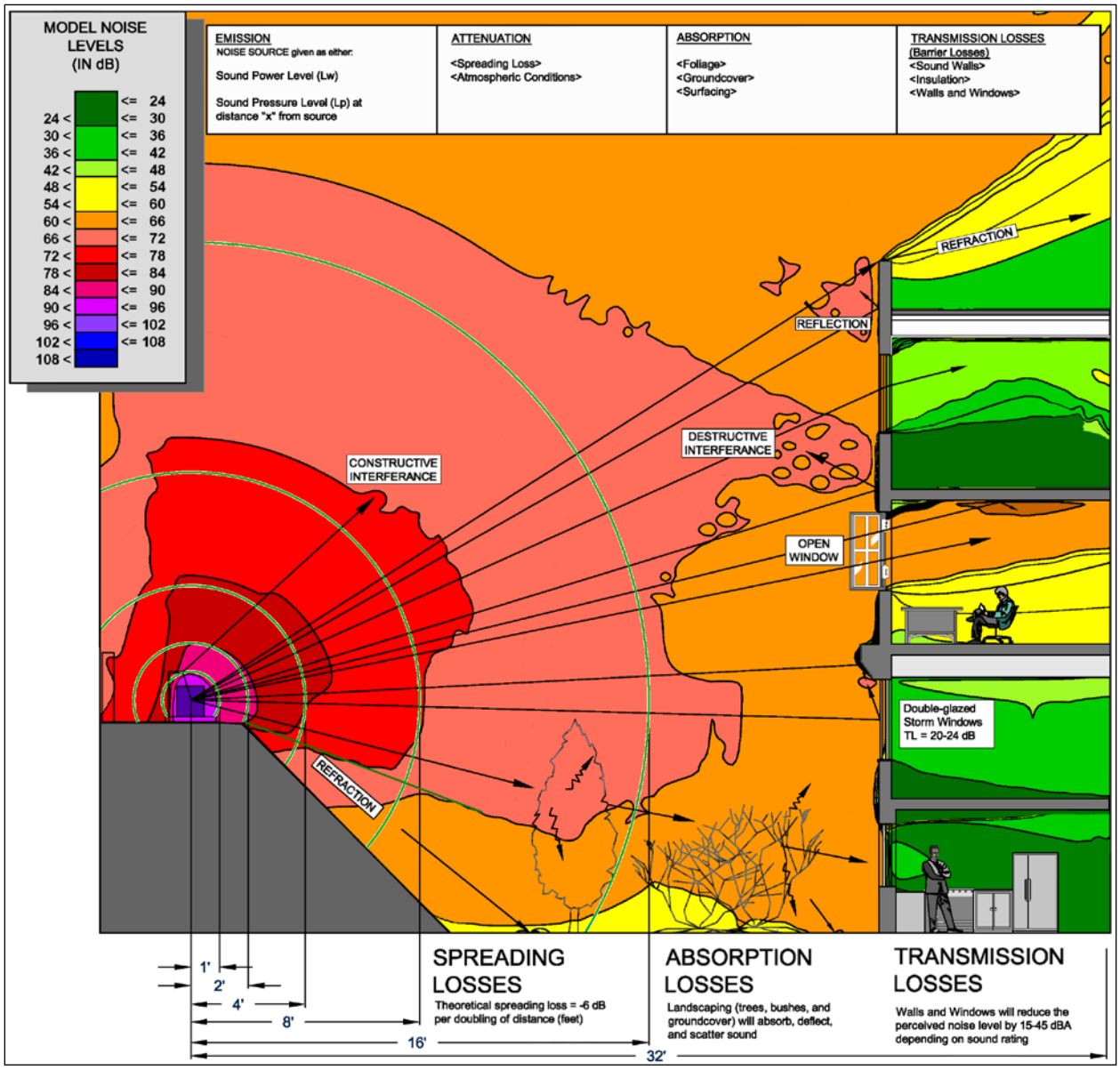

Figure 2-3 Emission, Attenuation, Absorption, and Transmission Loss

2.3.5 Sound Level Measurement

The dB scale is used to quantify sound intensity. Because SPLs can vary by over 1 million times within the range of human hearing, a logarithmic loudness scale (similar to the Richter Scale used for earthquake intensity) is used to keep sound intensity numbers within a manageable range. Since the human ear is not equally sensitive to all sound frequencies within the entire spectrum, noise measurements are weighted more heavily within those frequencies of maximum human sensitivity (middle A and its higher harmonics) in a process called "A-weighting," written as dBA.

Noise measurement metrics used for this analysis are as follows:

> Equivalent sound level (L_{eq}), the average sound level calculated from instantaneous measurements recorded over a specific period of time.

> Maximum sound level (L_{max}) reached during a sampling period. The L_{max} value is the peak noise level that occurred during the measurement period.

> Minimum sound level (L_{min}) reached during a sampling period. The L_{min} value obtained for a particular monitoring location typically reflects ambient conditions.

> Percentile sound levels (L_{90}, L_{50}, and L_{10}) are sound levels that exceed the percentile value during the measurement period.

> Community Noise Equivalent (CNEL): the average of the daytime measurement, evening measurement +5 dBA, and the night measurement +10 dBA.

> Day Night Level (L_{dn}): The day-night sound levelevaluator is recommended by the Environmental Protection Agency and used by most federal agencies as a land-use planning tool. It describes the average daily acoustic energy over the period of 1 year—meaning that moments of quiet are averaged together with moments where loud noises can be heard.

2.3.6 Community Noise Levels

Community noise levels depend on the intensity of nearby human activity. Noise levels are generally considered low when ambient levels are below 45 dBA, moderate in the 45 to 60 dBA range, and high above 60 dBA. In rural and undeveloped areas, L_{dn} can be below 35 dBA. Levels above 75 to 80 dBA are more common near major freeways and airports. Although people often accept the higher levels associated with very noisy urban areas, they nevertheless are considered to be adverse to public health. California uses a stricter equivalent sound level definition (CNEL), which uses the L_{dn} and adds a 5-dB penalty to sound measurements between 10:00 PM and 7:00 AM.

2.3.7 Noise Level Acceptance Criteria

The surrounding land uses dictate what noise levels would be considered acceptable or unacceptable. In rural and undeveloped areas away from roads and other human activity, the day-to-night difference is normally small. Because of diurnal activity, nighttime ambient levels in urban environments are about 7 dB lower than the corresponding daytime levels. Nighttime noise is a concern because of the likelihood of disrupting sleep. Noise levels above 45 dBA at night can result in the onset of sleep interference. At 70 dBA, sleep interference effects become considerable (USEPA 1974).

2.4 Noise Sources

Environmental noise sources are segregated into four categories: single event, mobile, stationary-temporary, and stationary-permanent. Examples of typical stationary and mobile noise sources in are presented in Table 2-1; noise sources that are most applicable to the equipment that would be used by the nine Districts in the Program alternatives are shown in bold. Construction noise sources are always

temporary and are typically mobile, but they may be stationary or single event. Construction noise sources are provided in more detail in Table 2-2.

Table 2-1 Typical Stationary and Mobile Noise Source Sound Levels in dBA

Noise Source	Sound Level in dBA at 50 feet[(1)]	Category
Sprayer, hand-held	**10-20**	**MOBILE**
Noise at ear level from rustling leaves	20	STATIONARY-TEMPORARY
Room in a quiet dwelling at midnight	32	STATIONARY
Soft whisper at 5 feet	34	STATIONARY-TEMPORARY
Large Department Store	50 to 65	STATIONARY-TEMPORARY
Room with window air conditioner	55	STATIONARY-PERMANENT
Leaf Blower/Vac	**55-105**	**MOBILE**
Conversational Speech	60 to 75	STATIONARY
Pump Station Equip. with Noise Abatement	62	STATIONARY-PERMANENT
Sprayer, powered, truck- or trailer-mounted	**65-105**	**MOBILE**
Passenger Car	69	MOBILE
Vacuum cleaner in private home at 10 feet	69	STATIONARY
Tractor, Agricultural at operator's seat	**76-110**	**MOBILE**
Ringing alarm at 2 feet	80	STATIONARY
Brush/Weed Cutter at operator	**90-97**	**MOBILE**
Roof-top Air Conditioner	85	STATIONARY-PERMANENT
Small Bulldozer (Cat D3) or Excavator (Cat 320)	**74-80**	**MOBILE**
Heavy Bulldozer	87	MOBILE
ATV at 5 to 15 feet	**87-109**	**MOBILE**
Heavy city traffic	90	MOBILE
Lawn mower at operator	**91-98**	**MOBILE**
Chain saw at operator	**100-120**	**MOBILE**
Jet aircraft at 500 feet overhead	115	MOBILE
Human pain threshold	120	--
Construction Blast	120 to 145	SINGLE EVENT

Sources: Noise Control Reference Handbook, Industrial Acoustics Company, 1979.

Notes:

Bold indicates Program equipment

[1] Noise level in dBA at approximately 50 feet unless otherwise noted in description

2.4.1 Traffic, Heavy Equipment, and Construction Noise

Although the nine Districts' ongoing mosquito and vector control activities do not involve heavy construction equipment besides bulldozers (for occasional use only), the information is provided for reference purposes.

Heavy equipment and construction noise sources and corresponding noise levels in the adjacent or nearby area will greatly fluctuate depending on the purpose of construction and the particular type, number, and duration of use of various types of construction equipment involved. Program equipment inventories include heavy equipment. The effect of construction noise on nearby receptors depends upon how much noise is generated by each individual piece of equipment; the distance between construction activities and the nearest noise-sensitive receptors; the frequency, type, and duration of noise produced; and the ambient noise levels at the receptors. At a distance of 50 feet, noise levels would be between 68 to 96 Leq. Noise levels in this range would be substantially higher than the ambient noise levels experienced by sensitive receptors in typical rural commercial, recreational, and residential environments.

For traffic noise, a change in noise levels of less than 3 dBA is not discernible to the general population. An increase in average noise levels of 3 dBA is considered barely perceptible, while an increase of 5 dBA is considered readily perceptible to most people (Caltrans 1998).

2.4.2 Characteristics of Groundborne Vibration

Vibrating objects in contact with the ground radiate vibration waves through various soil and rock strata to the foundations of nearby buildings. As the vibration propagates from the foundation throughout the remainder of the building, the vibration of floors and walls may cause perceptible vibration from the rattling of windows or a rumbling noise. The rumbling sound caused by the vibration of room surfaces is called groundborne noise. When assessing annoyance from groundborne noise, vibration is typically expressed as root mean square (rms) velocity in units of decibels of 1 micro-inch per second. To distinguish vibration levels from noise levels, the unit is written as "VdB." Human perception to vibration starts at levels as low as 67 VdB and sometimes lower. Annoyance due to vibration in residential settings starts at approximately 70 VdB. Groundborne vibration is almost never annoying to people who are outdoors. Although the motion of the ground may be perceived, without the effects associated with shaking of building components, the motion does not provoke the same adverse human reaction. In extreme cases, excessive groundborne vibration has the potential to cause structural damage to buildings. Common sources of groundborne vibration include trains and construction activities such as blasting, pile driving, and operating heavy earthmoving equipment.

Program equipment capable of producing ground-borne vibration is limited to bulldozer use. Excessive ground-borne vibration typically occurs when earthwork equipment encounters hard rock during construction, but such actions are not part of the Program alternatives. Occasional use of a small bulldozer may be required for activities such as vegetation clearance and unimproved road maintenance, but this would not result in human annoyance or structural damage from vibration. Similarly, light trucks, which would be used for each of the Program alternatives, would not be capable of producing substantial amounts of vibration.

2.4.3 Critical and Sensitive Receptors

Some land uses are generally regarded as being more sensitive to noise than others due to the types of population groups or activities involved. The definition of critical and sensitive receptors varies by jurisdiction, but in general, critical receptors are those that cannot be interrupted or disturbed by project noise. These include, but are not limited to, police and fire stations, high security operations, noise-sensitive industry, hospitals, nursing homes, and other long-term medical care facilities. Sensitive population groups include children and the elderly and sensitive land uses. These sensitive land uses include residential (single- and multi-family, mobile homes, dormitories, and similar uses), guest lodging, parks and outdoor recreation areas, schools, libraries, churches, and places of public assembly.

Biological receptors with the potential to be adversely affected by noise are primarily terrestrial wildlife species but may include water birds. The concern is whether the use of equipment could increase ambient noise levels. An additional concern is whether short-term or temporary increases in noise levels could affect sensitive wildlife receptors such as nesting eagles or other special-status raptors disrupting nesting, interrupting feeding of nestlings, or causing nest abandonment.

3 Regulatory Criteria

The noise nuisance criteria are derived from local noise ordinances, state laws, and/or federal regulations/standards. These criteria are programmatically evaluated in the PEIR to determine potential noise impacts from Program operations on receptors within the Program area.

3.1 Regulatory Setting

Federal regulations, standards, and guidelines; California state law; and local ordinances and regulations (LOR) pertaining to environmental noise are cited in this section. The LOR citations include all county ordinances and select city ordinances within the District Service Areas. Counties that do not have specific noise ordinances are either referenced as deferring to state or federal regulations, or if a noise element exists in a specific general plan, that element is cited.

3.2 Federal Standards

The federal noise standards or guidelines discussed in this section are applicable and relevant or to-be-considered during implementation of Program alternatives on federal lands including national wildlife refuges. Noise regulations and standards are provided for the following agencies:

> U.S. Department of Transportation (DOT) – Federal Aviation Administration (FAA)

> U.S. Department of Transportation (DOT) – Federal Highway Administration (FHWA)

> U.S. Environmental Protection Agency (USEPA)

3.2.1 U.S. Environmental Protection Agency (USEPA)

The USEPA has developed guidelines on recommended maximum noise levels to protect public health and welfare (EPA 1974). The USEPA does not enforce these regulations, but rather offers them as a planning tool for state and local agencies. The table below provides examples of protective noise levels recommended by the USEPA.

Table 3-1 USEPA Designated Noise Safety Levels

Effect	Noise Level	Area
Hearing Loss	Leq (24)<70 dB	All areas
Outdoor Activity Interference and Annoyance	Ldn <55 dB	Outdoors in residential areas and farms and other outdoor areas where people spend widely varying amounts of time and other places in which quiet is a basis for use.
	Leq (24)<55 dB	Outdoor areas where people spend limited amounts of time, such as school yards, playgrounds, etc.
Indoor Activity Interference and Annoyance	Ldn <45 dB	Indoor residential areas
	Leq (24)<45 dB	Other indoor areas with human activities such as schools, etc.

Source: USEPA, Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, March 1974.

L_{eq} (24) = Represents the sound energy averaged over a 24-hour period.

L_{dn} = Represents the Leq with a 10 dB nighttime weighting.

3.2.2 Federal Aviation Administration

The major parts of CFR Title 14: Aeronautics and Space, Chapter I: Federal Aviation Administration, Department of Transportation, Subchapter C, for fixed-wing aircraft noise and Subchapter H for helicopter noise, were reviewed for applicability to existing and potential Program flight operations, specifically:

Part 36: Noise Standards: Aircraft Type And Airworthiness Certification

Noise data from aircraft power plants, propellers, and combinations of each by aircraft type are well documented as each aircraft type must be certified by the FAA under Part 36 prior to use by general and commercial aviation.

The fixed-wing aircraft proposed for aerial spraying is an Air Tractor 502 . This aircraft make, model, engines, and propellers, as a system, are exempt from noise standards because the aircraft was manufactured for agricultural-type operations, including aerial spraying, exclusively. The helicopters proposed for aerial spraying have FAA noise certifications. Sound level data for the helicopters are presented in Section 4.

Part 91: Flight Operations

Elements of Part 91 are provided as a reference. Altitude limitations governing agricultural operations are given in Part 137, Agricultural Operations.

Fixed-wing aircraft not operating under an Instrument Flight Rules, emergencies, during takeoff or landing, or Part 137 are required to maintain the altitudes listed in Section 91.119 - Minimum Safe Altitudes: General (a)-(d). Section 91.119 (a), (b), and (c) are provided below.

Except when necessary for takeoff or landing, no person may operate an aircraft below the following altitudes:

(a) Anywhere. An altitude allowing, if a power unit fails, an emergency landing without undue hazard to persons or property on the surface.

(b) Over congested areas. Over any congested area of a city, town, or settlement, or over any open air assembly of persons, an altitude of 1,000 feet above the highest obstacle within a horizontal radius of 2,000 feet of the aircraft.

(c) Over other than congested areas. An altitude of 500 feet above the surface, except over open water or sparsely populated areas. In those cases, the aircraft may not be operated closer than 500 feet to any person, vessel, vehicle, or structure.

Section 137.49 – Operations over other than Congested Areas

Notwithstanding Part 91 of this chapter, during the actual dispensing operation, including approaches, departures, and turnarounds reasonably necessary for the operation, an aircraft may be operated over other than congested areas below 500 feet above the surface and closer than 500 feet to persons, vessels, vehicles, and structures, if the operations are conducted without creating a hazard to persons or property on the surface.

Section 137.51 – Operation over Congested Areas: General

(a) Notwithstanding Part 91 of this chapter, an aircraft may be operated over a congested area at altitudes required for the proper accomplishment of the agricultural aircraft operation if the operation is conducted:

  (1) With the maximum safety to persons and property on the surface, consistent with the operation, and

  (2) In accordance with the requirements of paragraph (i) of this section

(i) No person may operate an aircraft over a congested area except in accordance with the requirements of this paragraph.

(3) Prior written approval must be obtained from the appropriate official or governing body of the political subdivision over which the operations are conducted.

(4) Notice of the intended operation must be given to the public by some effective means, such as daily newspapers, radio, television, or door-to-door notice.

(5) A plan for each complete operation must be submitted to, and approved by appropriate personnel of the FAA Flight Standards District Office having jurisdiction over the area where the operation is to be conducted. The plan must include consideration of obstructions to flight, the emergency landing capabilities of the aircraft to be used, and any necessary coordination with air traffic control.

(6) Single engine aircraft must be operated as follows:

(i) Except for helicopters, no person may take off a loaded aircraft, or make a turnaround over a congested area.

(ii) No person may operate an aircraft over a congested area below the altitudes prescribed in Part 91 of this chapter except during the actual dispensing operation, including the approaches and departures necessary for that operation.

(iii) No person may operate an aircraft over a congested area during the actual dispensing operation, including the approaches and departures for that operation, unless it is operated in a pattern and at such an altitude that the aircraft can land, in an emergency, without endangering persons or property on the surface.

(7) Multiengine aircraft must be operated as follows:

(i) No person may take off a multiengine airplane over a congested area except under conditions that will allow the airplane to be brought to a safe stop within the effective length of the runway from any point on takeoff up to the time of attaining, with all engines operating at normal takeoff power, 105 percent of the minimum control speed with the critical engine inoperative in the takeoff configuration or 115 percent of the power-off stall speed in the takeoff configuration, whichever is greater, as shown by the accelerate stop distance data. In applying this requirement, takeoff data is based upon still-air conditions, and no correction is made for any uphill gradient of 1 percent or less when the percentage is measured as the difference between elevations at the end points of the runway divided by the total length. For uphill gradients greater than 1 percent, the effective takeoff length of the runway is reduced 20 percent for each 1 percent grade.

(ii) No person may operate a multiengine airplane at a weight greater than the weight that, with the critical engine inoperative, would permit a rate of climb of at least 50 feet per minute at an altitude of at least 1,000 feet above the elevation of the highest ground or obstruction within the area to be worked or at an altitude of 5,000 feet, whichever is higher. For the purposes of this subdivision, it is assumed that the propeller of the inoperative engine is in the minimum drag position, that the wing flaps and landing gear are in the most favorable positions, and that the remaining engine or engines are operating at the maximum continuous power available.

(iii) No person may operate any multiengine aircraft over a congested area below the altitudes prescribed in Part 91 of this chapter except during the actual dispensing operation, including the approaches, departures, and turnarounds necessary for that operation.

Section 137.53 – Operation over Congested Areas: Pilots And Aircraft

(a) General. No person may operate an aircraft over a congested area except in accordance with the pilot and aircraft rules of this section.

(b) Pilots. Each pilot in command must have at least:

(1) 25 hours of pilot-in-command flight time in the make and basic model of the aircraft, at least 10 hours of which must have been acquired within the preceding 12 calendar months.

(2) 100 hours of flight experience as pilot in command in dispensing agricultural materials or chemicals.

(c) Aircraft.

(1) Each aircraft must –

(i) If it is an aircraft not specified in paragraph (c)(1)(ii) of this section, have had within the preceding 100 hours of time in service a 100-hour or annual inspection by a person authorized by Part 65 or 145 of this chapter, or have been inspected under a progressive inspection system.

(ii) If it is a large or turbine-powered multiengine civil airplane of U.S. registry, have been inspected in accordance with the applicable inspection program requirements of Section 91.409 of this chapter.

(2) If other than a helicopter, it must be equipped with a device capable of jettisoning at least one-half of the aircraft's maximum authorized load of agricultural material within 45 seconds. If the aircraft is equipped with a device for releasing the tank or hopper as a unit, there must be a means to prevent inadvertent release by the pilot or other crewmember.

3.2.3 Federal Highway Administration

Title 23, Part 772 requires comprehensive noise studies using modeling for new construction or reconstruction of highways. The principle tool for evaluating noise impacts due to increased vehicular traffic is the Traffic Noise Model (TNM) latest version.

3.3 State Noise Standards and Guidelines

State noise standards and guidelines include CEQA, the California Department of Parks and Recreation General Plan, land use compatibility regulations and the California Vehicle Code. Elements of these are summarized below.

3.3.1 Department of Parks and Recreation General Plan

Statewide guidelines for General Plans published in 1998 indicate that levels under 70 Ldn should be acceptable to receptors in parks (OPR 1998).

The California Department of Parks and Recreation, Off-Highway Motor Vehicle Recreation Division published a comprehensive OHV noise study in September 2005 as required by Public Resources Code Section 5090.32(0). This division is responsible for enforcing OHV noise emissions violations on land regulated by the State (OPR 2005b).

3.3.2 Land Use Compatibility

The California Government Code § 65302(f) encourages each local government entity to conduct noise studies and implement a noise element as part of their General Plan. In addition, the California Office of Planning and Research published guidelines for evaluating the compatibility of various land uses as a

function of community noise exposure, and these are listed in Table 3-2 below. In general, noise levels less than 60 dBA Ldn are acceptable for all land uses, including residences, schools, and other noise-sensitive receptors. The State considers noise levels less than 70 dBA Ldn to be normally acceptable for playgrounds and neighborhood parks (OPR 1998).

It is important to note that the noise levels referred to above only consider permanent, stationary new noise sources. None of the operations involved in the Program are permanent, stationary noise sources so the table is provided for reference only.

Table 3-2 Land Use Compatibility for Community Noise Environment – Permanent Stationary Noise Sources

Land use category	Community Noise Exposure – L_{dn} or CNEL in dBA						
	50	55	60	65	70	75	80
Residential – Low Density Single Family, Duplex, Mobile Home							
Residential – Multifamily							
Transient Lodging – Motel, Hotel							
Schools, Libraries, Churches, Hospitals, Nursing Homes							
Auditorium, Concert Hall, Amphitheaters							
Sports Arena, Outdoor Spectator Sports							
Playgrounds, Neighborhood Parks							
Golf Courses, Riding Stables, Water Recreation, Cemeteries							
Office Buildings, Business Commercial and Professional							
Industrial, Manufacturing, Utilities, Agriculture							

LEGEND	
	Normally Acceptable: Specified land use is satisfactory, based upon the assumption that any buildings involved are of normal conventional construction, without any special noise insulation requirements.
	Conditionally Acceptable: New construction or development should be undertaken only after a detailed analysis of the noise reduction requirements is made and needed noise insulation features are included in the design.
	Normally Unacceptable: New construction or development should be discouraged. If new construction or development does proceed, a detailed analysis of the noise reduction requirement must be made and needed noise insulation features included in the design.
	Clearly Unacceptable: New construction or development generally should not be undertaken.

Source: State of California General Plan Guidelines, Office of Planning and Research, June 1998.'

CNEL = Community Noise Equivalent Level

dBA = A-weighted decibel(s)

Ldn = Day-Night Noise Level

3.3.3 California Vehicle Code

Noise from highway vehicles and off-highway equipment is regulated by the Department of Motor Vehicles with cooperation from the California Highway Patrol. Off-highway motor vehicles manufactured between 1975 and 1986 must not exceed 86 dBA, and those manufactured after 1986 must not exceed 82 dBA when measured at 50 feet from the centerline of travel (Vehicle Code Section 38370). Heavy highway vehicles manufactured after 1987 must emit less than 80 dBA (Vehicle Code Sections 27204 and 27206).

3.4 Selected Noise Ordinances within the Districts

Local ordinances and regulations (LOR) were obtained for selected localities within each of the nine Districts. Alameda County MAD and VCSD are combined. Selections were determined by geographical position, and, where identified during research, municipalities that have had historical noise issues related to similar Program-type operations.

Table 3-3 Summary of County and City Noise Ordinances or General Plan Elements Cited

Municipality	Ordinance Title/Description
Alameda County[(1)]	Alameda County General Ordinance Code, Title 6 Health and Safety, Chapter 6.60 Noise
Albany	Chapter VIII Law Enforcement, 8-1 Noise
Berkeley	Berkeley Municipal Code, Title 13, Chapter 13.40 Community Noise
Piedmont	Piedmont City Code, Chapter 12: Offenses – Misc. Sec. 12.8 Noise Declared Nuisance
Oakland	City of Oakland General Plan, Noise Element
San Leandro	Ordinance No. 2003-005
Contra Costa County[(2)]	County of Contra Costa, Noise Element, Contra Costa County General Plan, Chapter 11
Brentwood	Title 9 Public Peace, Morals, and Welfare, Chapter 32, Noise Regulations
El Cerrito	Title 10 Public Peace, Morals and Welfare, Chapter 10.30 Noise
Richmond	City of Richmond, Ordinance 14-11, Chapter 9.52, Community Noise Ordinance
San Ramon	Draft San Ramon General Plan 2030, Noise Element
Marin County[(1)]	Marin County Code of Ordinances, Title 6, Chapter 6.7-Loud and Unnecessary Noises
Fairfax	Municipal Code of Ordinances, Title 8, Chapter 8.20: Noise Control 8.20.050
Novato	The Novato General Plan, Chapter 5 Safety and Noise
San Rafael	San Rafael Code of Ordinances, Title 8, Morals and Conduct, Section 8.13, Noise.
Monterey County[(3)]	County of Monterey, Title 10 Health and Safety, Chapter 10.60 Noise Control
Monterey	City of Monterey City Code, Chapter 38 - Zoning Ordinance, Part I -- General Provisions
Salinas	Salinas Code of Ordinances, Chapter 21A. – Noise Regulation
Napa County[(1)]	County of Napa Municipal Code, Title 8 Chapter 8.16 Noise Control Regulations
Calistoga	City of Calistoga 2003 General Plan, Noise Element
Napa	City of Napa Municipal Code, Title 8, Chapter 8.08 Noise Control Regulations
Saint Helena	City of St Helena Code of Ordinances, Chapter 8.24, Noise
San Mateo County[(1)]	San Mateo County General Plan, Noise Element
Brisbane	Brisbane Municipal Code, Title 9 Public Peace, Morals, and Welfare
Redwood City	Redwood City New General Plan, Section 4.10 Noise and Vibration

Municipality	Ordinance Title/Description
San Mateo City	City Code Title VII – Health, Sanitation & Public Nuisances, 7.30 Noise Regulations
Woodside	Town of Woodside General Plan 2012, Noise Element
Santa Clara County[(1)(4)]	Code of Ordinances, Title B, Division B11, Chapter VIII Control of Noise and Vibration
Gilroy	City of Gilroy Zoning Ordinance, Section 41
San Jose	Title 10 Public Peace, Morals, and Welfare, Chapter 10-16.
Solano County[(2)]	Solano County General Plan, Health and Safety Element, Noise
Benicia	City of Benicia Code of Ordinances, Chapter 8.20, Noise
Los Gatos	Los Gatos General Plan 2020, Chapter 10
Sonoma County[(2)]	Sonoma County General Plan GP2020, Noise Element
Petaluma	City of Petaluma General Plan, Noise Element 10-P-3
Sebastopol	City of Sebastopol Noise Ordinance
Santa Rosa	Santa Rosa City Code, Title 17 Environmental Protection, Chapter 17-16 Noise

Notes:

(1) Noise LOR exempts Federal or State Preempted Activities.

(2) No county noise ordinance.

(3) Exemption based on distance but not specifically for public agency operations.

(4) Specific exemption for government helicopter noise.

3.4.1 Summary of LORs

The typical LOR requires non-residential operations such as construction or other noise-emitting activities related to commercial, industrial, and governmental operations to begin not before 7 am and end between 6 and 8 pm. Many limit work to non-weekend days, and some to Monday through Saturday. If operations are to occur outside of these periods, activities would either be required to comply with exterior and interior noise limits at residential and other sensitive receptors, or acquire a permit with the appropriate regulating agency. **Most noise ordinances exempt emergency operations and government operations where actions protect human health from exposure to potentially dangerous environmental and anthropogenic pathways.**

Seven of the nine counties within the Program area have specific noise ordinances. For example, Marin County allows for exceptions to their noise ordinance for emergency work [Section 6.70.030 (5) c]; and "emergency" is defined as "*a sudden, unexpected occurrence demanding immediate action to prevent or mitigate loss of, or damage to life, health, property, or essential public services (Section 22.130.030)*" (Marin County 2013). Of these seven counties with noise ordinances, six counties exempt actions performed by government entities are regulated by state or federal laws directly. The remaining county exempts all noise based on distance to the nearest occupied dwelling.

The typical noise ordinance generically states "it is unlawful for any person to operate any installed mechanical equipment if the maximum noise level exceeds 50 to 60 dBA at any point at least 1 foot inside the property line of the affected residential property and 3 to 5 feet above ground level." When measured from a distance of 50 feet, municipal vehicles and vehicles supporting government operations cannot exceed 70 to 85 dBA. Noise levels cannot exceed the ambient level by 10 dBA or more at schools, churches or hospitals. Municipal ordinances provide a single value for maximum noise levels permitted; the ranges given are from review of selected ordinances in the table above.

Many ordinances allow for very loud noise emissions on a short-term basis. The loudest noise may exceed the ordinance limit by, for example, 20 to 25 dB, but would be permitted for only 5 to 15 minutes. Noise that exceeds the ordinance limit by 10 to 15 dB may be permitted for up to an hour. Many Program noise sources fall within these parameters based on total time of use proposed and would not likely exceed ordinance limits at a single location.

4 Program Equipment and Vehicles Noise

The nine Districts provided tables of equipment and vehicles that would be used under each Program alternative with total time and days of use for each of five potential land use types that could be affected: residential, commercial, industrial, agricultural, and open space. Tables 4-1 through 4-9 below show the types of equipment and vehicles that would be used by each District, but they also include noise levels generated by each type of equipment or vehicles at distances of 50 feet and 400 feet from the source.

The noise levels are based on manufacturer data sheets, referenced studies, and noise databases. Where generic equipment names were given, either a range of sound levels or the maximum referenced level are provided. The maximum usage for multiples of the same equipment type for hours per day and days of per quarter is given. Equipment that is not loud enough to affect sensitive receptors for any operational use (i.e. is less than 45 dBA) are listed as "not of concern," abbreviated as NOC.

Table 4-1 Alameda County Mosquito Abatement District Vehicles and Equipment

Type of Vehicle/Equipment	Hours\day[1]	Days/Quarters				Noise Data in dBA at Indicated Distance		Notes
		Q1	Q2	Q3	Q4	50 feet	400 feet	
Pickup Truck 5.4L V8	4	50	57	55	45	83	65	At 35 mph. See also Note (2)
Pickup Truck 5.0L V8 (2)	3	53	60	55	50	83	65	
Pickup Truck 4.6L V8 (2)	2.5	58	60	58	55	83	65	
Pickup Truck 4.3L V6	4	0	0	1	0	83	65	
Pickup Truck 4.0L V6 (4)	3	55	60	55	40	83	65	
Pickup Truck 3.0L V6	6	0	43	62	22	83	65	
Cargo Van	2	8	15	6	5	83	65	
Jeep (2)	6	0	33	62	22	83	65	
SUV	2	20	15	20	15	83	65	
2001 6x6 Polaris ATV	2	1	2	0	0	87	69	(3)
Maruyama Mist Duster MD155DX	0.75	8	5	7	0	NOC		
Gas Spray Rig in Truck (2)	0.25	30	15	0	0	66	48	(4)
Electric Spray Rig (6)	0.15	0	10	20	1	63	45	
Leaf Blower	0.25	1	0	0	0	76	58	
Brush Cutter	0.5	0	0	0	1	63	45	
Chainsaw	0.5	0	0	0	1	70	50	
2008 ARGO 8/Wheel Avenger	4	30	15	0	0	87	69	(3)
2010/2012 ARGO 8/Wheel 750 HDI EFI (2)	4	30	15	0	0	87	69	(3)
Gas Spray Rig in Argo (3)	4	30	15	0	0	66	48	(4)
1968 Bell 206 Jet Ranger helicopter	4	0	1	0	0		84-87	(5)

Type of Vehicle/Equipment	Hours\day[1]	Days/Quarters				Noise Data in dBA at Indicated Distance		Notes
		Q1	Q2	Q3	Q4	50 feet	400 feet	
1989 Bell 206 Jet Ranger helicopter	4	0	1	0	0		84-87	(5)
1960 Hiller Soloy helicopter	4	0	1	0	0		83-89	Assumed (5)
Isolair Air spray system model 3900 (helicopter-mounted)	*						NOC	(6)
Isolair 4400 bucket system (helicopter-mounted)	*						NOC	
Isolair 4500 broadcaster (helicopter-mounted)	*						NOC	

NOC = Not of Concern

Notes:

(1) Locations will vary throughout listed period of use.

(2) Single hour time-weighted noise levels at 50 and 400 feet are 45 dBA and 34 dBA, respectively per TNM 2.5 Lookup Tables. Sound levels for vehicles varies greatly depending on speed, acceleration, braking, road type, and condition of vehicle. The values provided are very conservative.

(3) ATV range from reference California, 2005b.

(4) Based on sound power levels for typical 2.5-horsepower gasoline engine

(5) The noise values for aircraft (both fixed-wing and rotocraft) noise are approximately 500 feet from point of measure per FAA type certification. Aerial applications are done in response to elevated levels of larval mosquito production in large often difficult to access areas and are not necessarily used every year.

(6) Delivery vehicle noise is greater than 3 dB above equipment noise therefore the equipment noise is NOC

Table 4-2 Alameda County Vector Control Services District Vehicles and Equipment

Type of Vehicle/Equipment	Hours\day[1]	Days/Quarter				Noise Data in dBA at indicated distance		Notes
		Q1	Q2	Q3	Q4	50 feet	400 feet	
GMC Pickup Truck	8	90	91	92	92	83	65	At 35 mph. See also Note (2)
Ford Pickup Truck	8	90	91	92	92	83	65	
Dodge Pickup Truck	8	90	91	92	92	83	65	

Notes:

(1) Locations will vary throughout listed period of use.

(2) Single hour time-weighted noise levels at 50 and 400 feet are 45 dBA and 34 dBA, respectively per TNM 2.5 Lookup Tables.

Table 4-3 Contra Costa Mosquito and Vector Control District Vehicles and Equipment

Type of Vehicle/Equipment	Hours\day[1]	Days/Quarter				Noise Data in dBA at indicated distance		Notes
		Q1	Q2	Q3	Q4	50 feet	400 feet	
Chevy Pickup Truck[(15)]	2	30	65	65	30	83	65	At 35 mph. See also Note (2)
Chevy Pickup Truck[(7)]	2.75	0	65	65	0	83	65	
Chevy Pickup Truck[(3)]	1.5	15	30	30	15	83	65	
Chevy Pickup Truck[(6)]	0.5	0	5	5	0	83	65	
Toyota SUV[(2)]	1.0	8	8	8	8	83	65	
Chevy Sedan[(1)]	0.5	12	12	12	12	83	65	
Chevy Van[(1)]	1.0	2	0	0	2	83	65	
Hand Sprayer – Mozzie ULV Model 250[(2)]	2		1	7		87	69	Based on range of other hand sprayers
A-1 Mist Blower[(1)]	1.2		1	8		NOC		
Clarke-Cougar ULV[(1)]	2.5			9		63	45	Varies by nozzle and RPM
Maruyama Mist Duster MD155DX[(3)]	1.75	4	22	15		NOC		
Stihl SR420[(1)]	0.5		1			74	56	
Colt-T ULV[(1)]	0.75		6	8		87	69	Based on range of other ULV sprayers
LECO P-1 ULV[(2)]	1.0		1			87	69	Based on Range of other ULV sprayers
Gregor Boat[(1)]	0.5		1			90	72	
Argo ATV[(7)]	2.0	2	7.5	3.5		87	69	(3)
Polaris ATV[(2)]	1.0		8	10		87	69	(3)
1968 Bell 206 Jet Ranger helicopter	1		1				84-87	(4)
1989 Bell 206 Jet Ranger helicopter	1		1				84-87	(4)
1960 Hiller Soloy helicopter	1		1				83-89	Assumed (4)

NOC = Not of Concern

Notes:

(1) Locations will vary throughout listed period of use.

(2) Single hour time-weighted noise levels at 50 and 400 feet are 45 dBA and 34 dBA, respectively per TNM 2.5 Lookup Tables. Sound levels for vehicles varies greatly depending on speed, acceleration, braking, road type, and condition of vehicle. The values provided are very conservative.

(3) ATV range from reference California, 2005b.

(4) The noise values for aircraft (both fixed-wing and rotocraft) noise are approximately 500 feet from point of measure. Aerial applications are done in response to elevated levels of larval mosquito production in large often difficult to access areas and are not necessarily used every year.

Table 4-4 Marin-Sonoma Mosquito and Vector Control District Vehicles and Equipment

Type of Vehicle/Equipment (#)	Hours\day[1]	Days/Quarter				Noise Data in dBA at indicated distance		Notes
		Q1	Q2	Q3	Q4	50 feet	400 feet	
Chevy 3500 truck	1.0	4	15	15	2	85	67	At 35 mph. See also Note (2)
Ford F-250 truck (12)	2.0	50	60	60	40	83	65	
Ford F-250 truck 4x4 (9)	3.0	45	60	60	40	83	65	
Ford F-150 truck 4x4 (5)	1.5	10	15	15	5	83	65	
Ford F-350 truck (3)	3.0	10	15	15	5	85	67	
Ford Ranger truck 2x4 (3)	1.5	15	40	40	5	83	65	
Ford Ranger truck 4x4	0.5	3	5	5	1	83	65	
Ford F-550 4x4 (2)	3.0	5	15	15	2	85	67	
Intelli Truck 3500	1.0	3	4	1	0	85	67	
Chevy HD 2500 truck (3)	2.0	50	66	66	45	85	67	
Chevy W4500	1.0	0	1	3	0	85	67	
Ford Explorer (3)	1.0	32	48	48	32	83	65	
Ford Explorer 4x4	0.5	0	2	2	1	83	65	
Ford E-150 Van	1	0	7	7	1	83	65	
Dump Truck 5-ton	0.5	0	0	0	2	87	69	
Chevy Traverse	1.5	6	6	6	3	83	65	
Chevy 1500 Truck (2)	1.5	35	50	50	30	83	65	
Toyota Prius HB Three	2	63	63	63	63	83	65	
John Deere Tractor	2.0	0	2	1	0	76	58	
Argo Avenger (off-road) (5)	1	20	20	20	10	87	69	(3)
Argo Conquest (off-road) (4)	1	20	20	20	10	87	69	(3)
Arctic Cat 500 TBX (off- road) (2)	1	5	5	5	1		69	(3)
Kawasaki 400 (off- road)	1	5	5	5	1	87	69	(3)
Kawasaki 650 (off-road) (3)	2.5	10	20	30	15	87	69	(3)
Dondi Rotary Ditcher DMR35-B	1	1	0	0	1	NOC		
GO-4 Catch Basin Rig	2	1	5	5	5	NOC		
Komatsu (off-road)	2	0	2	2	0	87	69	(3)
Gator (off-road)	1	0	1	1	0	87	69	(3)
Pistenbully PB100 Mower	2.0	1	0	0	1	80	58	Estimated
Pistenbully 72F-H Mower	1.5	0	1	1	0	80	58	Estimated
Nifty-Fifty with Intelli reel	1	10	15	15	1	NOC		
Backpack fogger (Curtis Dynaflow) (5)	0.5	2	20	10	1	NOC		
Becomist Fogger (3)	1	2	15	10	2	50	NOC	

Type of Vehicle/Equipment (#)	Hours\day[1]	Days/Quarter				Noise Data in dBA at indicated distance		Notes
		Q1	Q2	Q3	Q4	50 feet	400 feet	
Electramist fogger	1	1	3	3	2	50	NOC	Assumed
Mozzie Fog Fogger	1	0	3	3	0	75	57	Based on ULV Fogger Range
Mozzie granular applicator	1	3	3	3	2	NOC		
Solo MD 150 DX [(5)]	1	10	30	30	15	NOC		Appears to be Maruyama Model #
Solo MD 155DX [(2)]	1	10	30	30	15	NOC		Appears to be Maruyama Model #
High Pressure sprayer	0.5	1	10	10	1	65	47	Generic. Approx. value listed
Echo Chainsaw	1.0	10	0	0	10	90	72	Varies by model, max. value listed
Echo hedge trimmer	1.0	5	0	0	5	51	NOC	Varies by model; value approx
Husqvarna Weedeater [(2)]	1.0	10	0	0	10	67	49	Varies by model; max value listed
Husqavarna Chainsaw [(2)]	0.5	5	0	0	5	72	54	Varies by model; max. value listed
Intelli sprayer 150	1.0	5	10	10	1	NOC		
Intelli sprayer 50	1.0	5	10	10	1	NOC		
'01 International 8000; 2,500-Gal Water Truck	2.0	2	2	2	1	75-88	57-70	Depends on gear and speed
'99 International 4700; 2,000-gal water truck	1.0	1	2	2	1	75-88	57-70	
'97 Ford Louisville 2,000-Gal water truck	1.0	1	1	1	1	75-88	57-70	
'99 Ford F550 Flat Bed 4X4 ruck	1.0	1	2	2	1	85	67	(2)
'05 Dodge 2,500 4X4 truck	1.0	3	3	3	2	85	67	
Airboat	1.0	2	10	10	5	85-95	67-77	At minimum speed to maintain planning conditions (4)
Grizzly 17 ft. Boat	1.0	1	1	1	1	75-85	57-67	Depends on engine
Klamath Boat	0.5	1	1	1	1	75-85	57-67	Depends on engine
Bell 206 Jet Ranger helicopter	2.0	2	5	5	2		84-87	(5)
1960 Hiller Soloy helicopter	2.0	1	1	1	1		84-89	Assumed (5)

NOC = Not of Concern

(1) Locations will vary throughout listed period of use.

(2) Single hour time-weighted noise levels at 50 and 400 feet are 45 dBA and 34 dBA, respectively per TNM 2.5 Lookup Tables. Sound levels for vehicles varies greatly depending on speed, acceleration, braking, road type, and condition of vehicle. The values provided are very conservative.

(3) ATV range from reference California, 2005b.

(4) Reference: Glegg, et.al., 2005

(5) The noise values for aircraft (both fixed-wing and rotocraft) noise are approximately 500 feet from point of measure. Aerial applications are done in response to elevated levels of larval mosquito production in large often difficult to access areas and are not necessarily used every year.

Table 4-5 Napa County Mosquito and Vector Control District Vehicles and Equipment

		Days/Quarter				Noise Data in dBA at indicated distance		
Type of Vehicle/Equipment (#)	**Hours\day[1]**	**Q1**	**Q2**	**Q3**	**Q4**	**50 feet**	**400 feet**	**Notes**
Chevy Pickup Trucks [6]	4.5	55	54	57	51	83	65	At 35 mph. See also Note (2)
Toyota Pickup Trucks [3]	3	4	28	20	11	83	65	
Jeep Wrangler	5.4	5	5	12	0	83	65	
Daewoo Forklift	0.5	12	8	6	10	64	46	Model-specific; max. value listed
Echo Chainsaw CS330T	2	5	0	0	10	90	72	Model-specific; max. value listed
FloTech Trash Pump	0.5	0	4	6	10	70	52	Model-specific; max. value listed
Stihl Blower BR420	1	0	3	3	1	53	NOC	Approx.
Stihl Weed Wackers [3]	6	10	0	5	10	66	48	Model-specific; max value listed
Northstar Pressure Washer	0.5	10	16	15	10	48	NOC	
Intellispray 9TBE	6	4	15	1	28	NOC		
JD9 ULV	4	0	3	2	0	75	57	Max. value listed
Intellispray 5SDE [4]	5.9	9	21	22	28	NOC		
Wisconsin Robin ULV	3	0	3	2	0	75	57	Max. value listed
Pioneer Backpack Fogger	2	0	12	10	0	NOC		
50-gal Polaris Spot Sprayer	4	3	4	3	1	87	69	
Maruyama Back Sprayers [2]	5	12	17	9	6	NOC		
London Fog 18-20 ULV [2]	2.5	0	13	6	0	61	NOC	Varies by model, nozzle, & rpm
London Fog XKE	1.5	0	5	0	0	61	NOC	Varies by model, nozzle, & rpm
Hand Sprayer, London Fog Colt	1	0	6	2	0	61	NOC	Varies by model, nozzle, & rpm
Tracker Boat	4	3	6	6	3	75-85	57-67	Depends on engine
Argo Sprayers [3]	5.7	5	6	2	2	66	48	
Polaris ATV [2]	5.1	6	15	2	1	87	69	(3)
Argo ATV [3]	4	4	7	6	3	87	69	(3)
Bell 206 Jet Ranger Helicopter	3	4	2	2	0		84-87	(5)
Hiller Soloy Helicopter	3	4	2	2	0		83-89	Assumed (5)

NOC = Not of Concern

[1] Locations will vary throughout listed period of use.

[2] Single hour time-weighted noise levels at 50 and 400 feet are 45 dBA and 34 dBA, respectively per TNM 2.5 Lookup Tables. Sound levels for vehicles varies greatly depending on speed, acceleration, braking, road type, and condition of vehicle. The values provided are very conservative.

[3] ATV range from reference California, 2005b.

[4] Reference: Glegg, et.al., 2005

[5] The noise values for aircraft (both fixed-wing and rotocraft) noise are approximately 500 feet from point of measure. Aerial applications are done in response to elevated levels of larval mosquito production in large often difficult to access areas and are not necessarily used every year.

Table 4-6 Northern Salinas Valley Mosquito Abatement District Vehicles and Equipment

Type of Vehicle/Equipment (#)	Hours\day[1]	Days/Quarter				Noise Data in dBA at indicated distance		Notes
		Q1	Q2	Q3	Q4	50 feet	400 feet	
Chevy Silverado 4X4	16 hrs/mo	23	23	23	23	83	65	At 35 mph. See also Note (2)
Dodge Ram 50 Right hand drive	10 hrs/yr	23	23	23	23	83	65	
Jeep Liberty 4X4	2 hrs/mo	23	23	23	23	83	65	
Jeep Wrangler 4X4	4 hrs/mo	23	23	23	23	83	65	
Ford F-150 4X4 Flare Side	16 hrs/yr	23	23	23	23	83	65	
Ford F-150 4X4 [3]	4 hrs/day	23	23	23	23	83	65	
Ford F-150 Xl	4 hrs/day	23	23	23	23	83	65	
Ford F-350 4X4	16 hrs/mo	23	23	23	23	85	63	(2)
Ford Windstar Sport SE	8 hrs/mo	23	23	23	23	83	65	(2)
Stihl Chainsaw 028 AV Super	8 hrs/yr	23	23	23	23	90	72	Generic Range
Stihl Chainsaw 011AV	8 hrs/yr	45	45	45	0	90	72	Generic Range
Stihl Leaf Blower BG 65	0	00	45	45	0	69	51	
Bean Pump	8 hrs/mo	23	23	23	23	NOC		
Maruyama Backpack Blower	12 hrs/yr	23	23	23	23	NOC		
Cat 320 Excavator	150 hrs/yr	15	32	32	15	56	NOC	Assumes light duty
Cat D3 Dozer	100 hrs/yr	15	32	32	15	62	NOC	Assumes light duty
John Deere 6420 with Flail Mulch Mower S900 (PTO)	100 hrs/yr	15	32	15	15	80		Generic Tractor Range
Blow Mite Granule Spreader (backpack)	8 hrs/yr	23	23	23	23	NOC		
Robin Micro Gen Fogger	8 hr/yr	23	23	23	23	NOC		
Mozzie Fogger – Arro-Gun System	8 hrs/yr	23	23	23	23	NOC		
Mozzie Granular Applicator, Arro-Gun System	8 hrs/yr	23	23	23	23	NOC		
GPI Model 1505 Fuel Transfer	8 hrs/year	23	23	23	23	54	NOC	
Argo ATV	8 hrs/mo	23	23	23	23	87		(3)
Argo Sprayer System	8 hrs/mo	23	23	23	23	66	48	
Valco Flat Bottom Boat (go devil engine/prop)	8 hrs/mo	23	23	23	23	85-95		Assumed
Bell Jet Ranger	40/yr	23	23	23	23		84-87	

NOC = Not of Concern

(1) Locations will vary throughout listed period of use.

(2) Single hour time-weighted noise levels at 50 and 400 feet are 45 dBA and 34 dBA, respectively per TNM 2.5 Lookup Tables. Sound levels for vehicles varies greatly depending on speed, acceleration, braking, road type, and condition of vehicle. The values provided are very conservative.

(3) ATV range from reference California, 2005b.

(4) Reference: Glegg, et.al., 2005

(5) The noise values for aircraft (both fixed-wing and rotocraft) noise are approximately 500 feet from point of measure. Aerial applications are done in response to elevated levels of larval mosquito production in large often difficult to access areas and are not necessarily used every year.

Table 4-7 San Mateo County Mosquito and Vector Control District Vehicles and Equipment

Type of Vehicle/Equipment (#)	Hours\day[1]	Days/Quarter				Noise Data in dBA at indicated distance		Notes
		Q1	Q2	Q3	Q4	50 feet	400 feet	
Chevy 2500 pickup truck 4x4						83	65	At 35 mph. See also Note (2)
Ford F-150 pickup truck 4x4						83	65	
Hyundai Sonata Hybrid						83	65	
Ford Escape Hybrid 4x4						83	65	
Jeep Wrangler (Right Hand Drive)						83	65	
Ford Ranger pickup truck 4x4						83	65	
Nissan Frontier Pro4X pickup truck 4x4						83	65	
Toyota Sienna Van	2	15	15	15	15	83	65	
Nurse Rig 200 gal tank and sprayer	3	5	3	30	15	NOC		
Argo Avenger (off road)	4	5	5	0	5	87	59	(3)
Fork Lift - hydraulic	>1	5	5	5	5	59-63	NOC	Generic range
Porta-Pak ULV Backpack Sprayer	>1	2	10	10	2	75	57	
Maruyama Power Mister/Duster Backpack Sprayer	>1	5	10	10	5	NOC		
Curtis Dyna-Fog Twister XL ULV Backpack Sprayer	>1					NOC		
Clark Grizzly ULV Truck Mounted Sprayer	12	20	20	20	20	87	59	Based on USDA Report; Varies by nozzle, RPM
Univar Dynajet ULV Electric Truck Mounted Sprayer	12*	20	20	20	20	50	NOC	70 dB at nozzle
Hotsy High Pressure Washer	1	50	50	50	50	65	47	Estimated
Dewalt 10” Compound Miter Saw DW703	>1	>1	>1	>1	>1	66	48	Estimated
Dewalt 14” Multicutter Metal Saw	>1	>1	>1	>1	>1	83	61	Approx.
Chicken coops for sentinel chickens						44-90		Varies by Chicken/Rooster type, and activity level
Stihl Chainsaw 026	1	2	5	3	3	90	72	Generic Range Given
Stihl Chainsaw 021	1	2	5	3	3	90	72	Generic Range Given
Stihl Chainsaw 039	>1	>1	>1	>1	>1	90	72	Generic Range Given
Stihl Chainsaw 290	1	2	5	3	3	73	55	

Type of Vehicle/Equipment (#)	Hours\day[1]	Days/Quarter				Noise Data in dBA at indicated distance		Notes
		Q1	Q2	Q3	Q4	50 feet	400 feet	
Stihl Chainsaw 260	1	2	5	3	3	81	63	
ECHO Chainsaw CS 301	2	4	10	6	6	90	72	Generic Range Given
Stihl Trimmer HS 85	6		60	30		51	NOC	Approx. Generic Value Given
ECHO Weedeater SRM 225	2		5	5		69	51	Generic Range given
Stihl Weedeater FS 250	2		5	5		76	58	
05 Dodge 2500 4X4 truck	5	1	1	3	1	83	65	(2)
GTO Airboat	3	10	10	20	20	85-95		(4)
GTO Airboat 50 gallon spray tank	5	0	0	15	15	NOC		(6)
Klamath Boat 14’	3	2	2	2	2	75-85	57-67	Depends on engine
Klamath Boat 18’	2	5	5	5	5	75-85	57-67	Depends on engine
Argo Avenger (off road)	16	40	20	0	12	87		(3)
1989 Bell 206 Jet Ranger helicopter	4	2	2	2	2		84-87	(5)
Isolair Air spray system model 3900 (helicopter-mounted)	8	2	0	0	0	NOC		(6)
Isolair 4500 broadcaster (helicopter-mounted)	2	0	2	2	0	NOC		(6)

NOC = Not of Concern

(1) Locations will vary throughout listed period of use.

(2) Single hour time-weighted noise levels at 50 and 400 feet are 45 dBA and 34 dBA, respectively per TNM 2.5 Lookup Tables. Sound levels for vehicles varies greatly depending on speed, acceleration, braking, road type, and condition of vehicle. The values provided are very conservative.

(3) ATV range from reference California, 2005b.

(4) Reference: Glegg, et.al., 2005

(5) The noise values for aircraft (both fixed-wing and rotocraft) noise are approximately 500 feet from point of measure. Aerial applications are done in response to elevated levels of larval mosquito production in large often difficult to access areas and are not necessarily used every year.

(6) Delivery vehicle noise is greater than 3 dB above equipment noise therefore the equipment noise is NOC.

Table 4-8 Santa Clara County Vector Control District Vehicles and Equipment

Type of Vehicle/Equipment (#)	Hours\day[1]	Days/Quarter				Noise Data in dBA at indicated distance		Notes
		Q1	Q2	Q3	Q4	50 feet	400 feet	
Ford Personnel Van[(1)]	1	30	30	30	30	83	65	At 35 mph. See also Note (2)
Dodge Pickup truck[(1)]	2	30	30	30	30	83	65	
Ford F150 [(14)]	3	60	60	60	60	83	65	
Dodge ¾ ton[(1)]	4	0	60	60	10	85	67	
GMC ½ ton[(5)]	2	5	30	30	5	85	67	
Ford Escape[(1)]	1	20	20	20	20	83	65	
Ford F250[(10)]	3	60	60	60	60	83	65	
Ford Ranger[(5)]	6	25	60	60	15	83	65	
Ford Expedition	1	45	45	45	45	83	65	
International flatbed truck	1	3	2	2	3	85	67	
Fork Lift[(1)]	1	10	10	10	10	59	NOC	
Argo Avenger ATV[(2)]	2 .75 hrs	13	13	13	13	87	59	(3)
Kabota	1.44 hrs	3	3	3	3	76	58	Generic Tractor Range Given
Boat	12 min	0.5	0.5	0.5	0.5	NOC		Based on limited time of use
Yamaha Quads[(2)]	2.6 hrs	14	14	14	14	87	59	(3)
Argo Conquest	3 hrs	8	8	8	8	87	59	(3)
Alpine Helicopter Services	45 min	1	0	0	0	NOC		Based on limited time of use

NOC = Not of Concern

(1) Locations will vary throughout listed period of use.

(2) Single hour time-weighted noise levels at 50 and 400 feet are 45 dBA and 34 dBA, respectively per TNM 2.5 Lookup Tables. Sound levels for vehicles varies greatly depending on speed, acceleration, braking, road type, and condition of vehicle. The values provided are very conservative.

(3) ATV range from reference California, 2005b.

Table 4-9 Solano County MAD Vehicles and Equipment

Type of Vehicle/Equipment (#)	Hours\day[1]	Days/Quarter				Noise Data in dBA at indicated distance		Notes
		Q1	Q2	Q3	Q4	50 feet	400 feet	
Chevrolet Astro Van	1	60	60	60	50	83	65	At 35 mph. See also Note (2)
Ford Pickup Trucks[(7)]	4	50	60	60	50	83	65	
Clark Forklift	0.5	5	5	5	5	68	50	
Kubota Tractor	1	5	5	5	5	76	58	Generic Tractor Range Given
Pro-Mist 25HD	1	0	10	2	8	50	NOC	
Leco 500 ULV Fogger x2	2	0	5	2	8	87	69	Varies by model, nozzle, & RPM
London Fog M.A.G. ULV Fogger x3	2	0	15	15	5	61	NOC	
Colt handheld ULV Fogger x 6	0.5	0	10	4	0	66	48	(4)
Snapper Rear Engine Riding Mower	1	10	10	10	10	65	47	
Toro Push Mower	1	5	5	5	5	61	NOC	
Stihl 025 Chainsaw	.1	1	1	0	0	90	72	
Stihl FS83 Weedeater	0.5	10	15	15	10	59	NOC	
Stihl HS Hedge trimmer	1	0	2	2	0	63	NOC	
Stihl BG55 Leaf Blower	1	10	15	15	10	69	51	
Craftsman 24” Leaf Vac	1	1	0	0	1	55-75	57	Varies by model and type (gas/electric)
Maruyama MD155DX Backpack Sprayer	1	5	10	10	0	NOC		
Argo ATV Magnum	2	0	0	0	2	87	69	(3)
Argo ATV Conquest	4	0	0	5	15	87	69	(3)
Argo ATV Avenger	4	4	8	8	20	87	69	(3)
Argo ATV Avenger	3	15	10	6	10	87	69	(3)
Honda ATV TRX500FM	3	0	8	8	0	87	69	(3)
Honda ATV TRX400FE	2	0	6	6	0	87	69	(3)
Honda ATV TRX350FM	3	0	15	15	0	87	69	(3)
Honda ATV TRX300FW[(2)]	1	0	2	2	0	87	69	(3)
Invader boat 19	2	0	0	4	0	75-85	57-67	Varies by power setting
Achilles Inflatable boat	2	0	0	2	0	75-85	57-67	Varies by power setting

Type of Vehicle/Equipment (#)	Hours\day[1]	Days/Quarter				Noise Data in dBA at indicated distance		Notes
		Q1	Q2	Q3	Q4	50 feet	400 feet	
1968 Bell 206 Jet Ranger helicopter	2	2	0	0	0		84-87	(5)
1989 Bell 206 Jet Ranger helicopter	2	2	0	0	0		84-87	(5)
1960 Hiller Soloy helicopter	2	2	0	0	0		84-87	Estimated (5)
Isolair Air spray system model 3900 (helicopter-mounted)	2	6	0	0	0	NOC		(6)
Isolair 4400 bucket system (helicopter-mounted)	1	2	0	0	0	NOC		(6)
Isolair 4500 broadcaster (helicopter-mounted)	4	4	6	10	14	NOC		(6)
Fixed Wing Aircraft Air Tractor 502	4	4	6	10	14	NA		Not Applicable – Agricultural aircraft are exempt under FAR 36.1(a)(2) and 36.1583.

NA = Not Applicable

NOC = Not of Concern

(1) Locations will vary throughout listed period of use.

(2) Single hour time-weighted noise levels at 50 and 400 feet are 45 dBA and 34 dBA, respectively per TNM 2.5 Lookup Tables. Sound levels for vehicles varies greatly depending on speed, acceleration, braking, road type, and condition of vehicle. The values provided are very conservative.

(3) ATV range from reference California, 2005b.

(4) Based on sound power levels for typical 2.5-horsepower gasoline engine.

(5) The noise values for aircraft (both fixed-wing and rotocraft) noise are approximately 500 feet from point of measure. Aerial applications are done in response to elevated levels of larval mosquito production in large often difficult to access areas and are not necessarily used every year.

(6) Delivery vehicle noise is greater than 3 dB above equipment noise therefore the equipment noise is NOC.

5 Best Management Practices

The following Best Management Practices could be implemented by any of the Districts for any operations that use equipment that may generate noise levels approaching or above significance thresholds at sensitive receptors for even short periods of time.

> Measure 1: Provide Advance Notices. Provide nearby residents and businesses 48-72 hours of advanced notice of project activities, schedule, anticipated traffic, and potential noise issues. The advance notice will describe the potential noise disruption and the steps the District or its contractor plans to take to minimize the noise (for example, by enclosing and muffling equipment, limiting idling and engine brake use). If the activities are delayed due to operational issues or weather delays of more than 1 week, an additional notice will be provided.

> Measure 2: Provide Liaison and Hotline for Nuisance Complaints. The District will provide a liaison to respond to concerns of noise from Program operations. Procedures for reaching the liaison via telephone or in person will be included in notices distributed and posted in accordance with Measure 1. Nuisance complaints filed with the liaison, and the approach used to resolve the complaint, will be reported to the District.

> Measure 3: Properly Maintain Equipment. The application contractor will properly maintain and tune engines of all applicable equipment and maintain properly functioning mufflers on all internal combustion engines to minimize noise levels. Perform noise reduction maintenance during routine maintenance for each vehicle serviced.

> Measure 4: Follow Established Procedures for Aircraft Operations. The District will implement feasible and appropriate measures to ensure aircrew stay within the flight plan published. Measures include daily preflight and post-op briefings, written flight envelope procedures, and review of recorded Global Positioning System (GPS) flight data (including altitude). Complaints filed with the District contractor and the approach used by the aerial application contractor(s) to resolve the complaint will be reported to the District.

> Measure 5: Follow Established Procedures for Airboat Operations. The District will implement feasible and appropriate measures to ensure operators stay within the treatment area published. Measures include daily tailgate meetings and post-operational briefings, mapped operational areas that are permitted with recorded GPS route data. Complaints filed with the District contractor and the approach used by the aerial application contractor(s) to resolve the complaint will be reported to the District.

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Integrated Vector
Management Program

APPENDIX

E

ALTERNATIVES ANALYSIS REPORT

MARIN/SONOMA MOSQUITO & VECTOR CONTROL DISTRICT

Protecting Public Health Since 1915

Document Information

Prepared by	Marin/Sonoma Mosquito & Vector Control District
Project Name	Integrated Vector Management Program Draft Programmatic Environmental Impact Report
Date	July 2014

SCREENCHECK DOCUMENT

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Introduction

This report documents the analysis of alternatives for the control of mosquitoes and/or other vectors within the District's immediate Service Area, and when necessary in adjacent counties to assist in those areas as well. The Service Area and the adjacent counties are called the Program Area for purposes of environmental impact analysis under the California Environmental Quality Act (CEQA). This report is provided as Appendix E, Alternatives Analysis Report, to the District's Programmatic Environmental Impact Report (PEIR). It presents a list of potential alternatives or "tools" and screening criteria to produce recommended components of the Proposed Program. These components represent a reasonable range of alternatives to be discussed in the environmental consequences/impacts sections of the PEIR on the entirety of the District's Program.

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1 Program Background

The Marin/Sonoma Mosquito & Vector Control District (District) has evaluated a range of control methods for mosquitoes and other vectors of human disease and discomfort in its Service Area, comprised of Marin and Sonoma counties. The District will continue to develop the most effective strategy and methods or "tools" to achieve Program objectives in order to protect human and animal health.

1.1 Program Location

The District's Program Area is located in the following counties of the state of California: Marin and Sonoma. The areas proposed for control activities cover an area of approximately 2,100 square miles. These activities would be focused in the areas with the greatest problems based on vector surveillance, vector surveillance associated with service requests from the public, and surveillance and testing for presence of the disease pathogens.

1.2 Program History

The original part of the District was established in 1915 to provide mosquito and/or vector control services to the residents and businesses of Marin County. In 1976, the District annexed the central area of Sonoma County, becoming the Marin/Sonoma Mosquito Abatement District. The Town of Sonoma and surrounding areas were annexed into the District in 1982, and in 2004, voters approved the annexation of all remaining unincorporated areas of Marin and Sonoma counties, thus making vector control services available to all residents of the two counties.

The District's Program is an ongoing series of related actions for control of mosquitoes and other vectors of human disease and discomfort. The District's activities involve the identification of vector problems; responsive actions to control existing populations of vectors, preventing new sources of vectors from developing, and managing habitat to minimize vector production; the education of landowners and others on measures to minimize vector production or interaction with vectors; and the provision and administration of funding and institutional support necessary to accomplish the District's objectives.

The District has, for at least the past two decades, taken an integrated systems approach to mosquito and vector control, utilizing a suite of tools that consist of public education and outreach surveillance, vegetation management, and physical, biological, and chemical controls. These Program "tools" or components are described in the subsequent subsection as "Program alternatives" for the California Environmental Quality Act (CEQA) process (except for public education, which is exempt from CEQA). Program implementation is weighted heavily towards public education, vegetation management and physical and biological control, in part, to reduce the potential for environmental impacts. To realize effective and environmentally sound vector management, vector control must be based on several factors:

> Public Education, outreach, and interaction

> Carefully monitoring or surveying vector abundance and/or potential contact with people

> Establishing treatment guidelines

> Selecting appropriate tools from a wide range of control methods

This ongoing Program consists of a dynamic combination of surveillance, treatment guidelines, and use of multiple control activities in a coordinated program with public education that is generally known as Integrated Pest Management (IPM) or Integrated Vector Management (IVM).

While these Program components or tools together encompass the District's IVM Program (IVMP), it is important to acknowledge that the specific tools utilized by District staff vary from day to day and from site

to site in response to the vector species that are active, their population size or density, their age structure, location, time of year, local climate and weather, potential for vector-borne disease, proximity to human populations, including:

> proximity to sensitive receptors,

> access by District staff to vector habitat,

> abundance of natural predators,

> availability and cost of control methods,

> history of effectiveness of previous control efforts at the site,

> potential for development of resistance in vector populations,

> landowner policies or concerns,

> proximity to special-status species, and

> applicability of Endangered Species Recovery Plans, Habitat Conservation Plans, Natural Community Conservation Plans, and local community concerns, among other variables.

Therefore, the specific actions taken in response to current or potential vector activity at a specific place and time depend on factors of vector and pathogen biology, physical and biotic environment, human settlement patterns, local standards, available control methods, and institutional and legal constraints. While some consistent vector sources are exposed to repeated control activity, many areas with minor vector activity are not routinely treated, and most of the land within the District's Service Area has never been directly treated for vectors.

2 Potential Tools

Potential tools for use in the Program are described below and include measures used for other similar control programs in California. This chapter presents a brief description of each tool. The evaluation of each as to whether it is applicable to or an effective component of a mosquito and/or vector control program is presented briefly here, but explained further in Section 3.

2.1 Integrated Pest Management

2.1.1 Description

Integrated pest management (IPM) is a decision making process that involves the use of one or more tools to prevent pest numbers from reaching damaging levels. Important components of a successful IPM program are: selecting a proactive approach; identifying the pest; understanding pest biology, behavior, and population dynamics; monitoring pest numbers; establishing treatment guidelines or threshold levels to trigger actions that will prevent damage or loss; selecting the appropriate tool to prevent pest numbers from reaching harmful levels; implementing management tools in a timely manner; following-up with evaluation on effectiveness and any unintended impacts of management actions taken; and recognizing that often some damage due to pest presence may occur and is acceptable.

2.1.2 Examples of Tool Use

Integrated Pest Management is used in nearly all crop systems and by all vector control agencies in California as Integrated Vector Management (IVM), a specialized form of IPM.

2.1.3 Applicable to District IVMP

The District's current IVMP uses the key concepts of IPM. Where IPM controls pest numbers and believes that some crop damage is acceptable, the District has instances in which the threat to public health from vectors of human and animal disease requires additional measures that go beyond traditional IPM to be taken.

2.2 Vector Surveillance

2.2.1 Description

Vector surveillance, which is an integral part of the District's responsibility to protect public health and welfare, involves monitoring vector populations and habitat, their disease pathogens, and human/vector interactions. Vector surveillance provides the District with valuable information on what vector species are present or likely to occur, when they occur, where they occur, their population sizes, and if they are carrying pathogens or otherwise affecting humans. Vector surveillance is critical to an IVM program because the information it provides is evaluated against treatment guidelines to decide when and where to institute vector control measures. Information gained is used to help form action plans that can also assist in reducing the risk of pathogen transmission and disease occurrence. Equally important is the use of vector surveillance in evaluating the efficacy, cost effectiveness, and environmental impacts of specific vector control actions.

2.2.2 Examples of Tool Use

Examples include field counting/sampling and trapping, arbovirus surveillance, field inspection of known or suspected habitats, and public service requests.

2.2.3 Applicable to District IVMP

Already used under current Program.

2.3 Physical Control

2.3.1 Description

Physical control is managing vector habitat to reduce and possibly eliminate vector production and dispersal through “source reduction’” measures that are comprised of nonchemical or nonbiological techniques. In many cases, physical control activities involve restoration and enhancement of natural ecological functioning. For mosquitoes, these activities include, but are not limited to, water management and maintenance of channels, tide gates, levees, and other water control facilities to improve water circulation.

2.3.2 Examples of Tool Use

The District routinely undertakes source reduction projects in cooperation with other agencies. An example is water circulation improvement work performed with the California Department of Fish and Wildlife at the Petaluma Marsh. Another example is a project planned and carried out in conjunction with U.S. Fish and Wildlife Service that improved tidal circulation in Lower Tolay Creek in Sonoma County. Both projects significantly reduced the potential for mosquito production in the respective areas.

2.3.3 Applicable to District IVMP

Already used under current Program.

2.4 Vegetation Management

2.4.1 Description

The species composition and density of vegetation are basic elements of the habitat value of any area for mosquitoes and other vectors, for predators of these vectors, and for protected flora and fauna. District staff routinely undertakes vegetation management activities as a tool to reduce the habitat value of sites for mosquitoes and other vectors or to aid production or dispersal of vector predators, as well as to allow access by District staff to vector habitat for surveillance and other control activities. Direct vegetation management by District staff generally consists of activities to reduce the mosquito habitat value of sites by improving water circulation or access by fish and other predators, or to allow access by District staff to standing water for inspections and treatment. For vegetation management, the District uses hand tools or other mechanical means (i.e., heavy equipment) for vegetation removal or thinning and sometimes applies herbicides (chemical pesticides with specific toxicity to plants) to improve surveillance or reduce vector habitats. Vegetation removal or thinning primarily occurs within or adjacent to aquatic habitats to assist with the control of mosquitoes and in terrestrial habitats to help with the control of other vectors.

2.4.2 Examples of Tool Use

Trimming of vegetation to allow access to water sources such as creeks, low areas, seasonal wetlands, ponds and floodplains. Mowing of access paths in dense stands of cattails to facilitate access for mosquito surveillance and larvicide treatment.

2.4.3 Applicable to District IVMP

Already used under current Program.

2.5 Biological Control Pathogens (Viruses)

2.5.1 Description

Mosquito pathogens are highly host-specific and usually infect mosquito larvae when they are ingested. Upon entering the host, these pathogens multiply rapidly, destroying internal organs and consuming nutrients. The pathogen can be spread to other mosquito larvae in some cases when larval tissue disintegrates and the pathogens are released into the water to be ingested by uninfected larvae.

2.5.2 Examples of Tool Use

Examples of viruses that can infect mosquitoes are mosquito iridoviruses, densonucleosis viruses, nuclear polyhedrosis viruses, cytoplasmic polyhedrosis viruses, and entomopoxviruses.

2.5.3 Applicable to District IVMP

These viruses are not commercially available for mosquito control at present. Becnel and White (2007) provide a thorough summary of the current understanding and last 20 years of research concerning mosquito pathogenic viruses. Their review indicates there are still numerous issues to be addressed before mosquito viral pathogens can be used as an effective mosquito control strategy.

2.6 Biological Control Pathogens (Bacteria)

2.6.1 Description

Mosquito pathogens are highly host-specific and usually infect mosquito larvae when they are ingested. Upon entering the host, these pathogens multiply rapidly, destroying internal organs and consuming nutrients. The pathogen can be spread to other mosquito larvae in some cases when larval tissue disintegrates and the pathogens are released into the water to be ingested by uninfected larvae. . Environmental factors such as salinity, low temperatures, high larval densities, life stage (age) of the mosquito, and dense vegetative cover that interferes with application at the mosquito-breeding site can limit the effectiveness and presence of certain bacterial pathogens of mosquitoes. For example, *Bacillus sphaericus* (Bs) works best in highly polluted waters but not very well in brackish or saline environments. The species of mosquito may also play a role in effectiveness (e.g. several species of *Aedes* mosquitoes, including salt marsh *Aedes*, are not very susceptible to the larvicide Bs (Baumann et al., 1991; Davidson, 1989; Mittal, 2003).

2.6.2 Examples of Tool Use

The only live bacteria commercially available and pathogenic to mosquitoes is *Bacillus sphaericus* (Bs). This material is currently available as a granule (VectoLex FG), water dispersible granule (VectoLex WDG), and water-soluble packet (VectoLex WSP) for the treatment of immature mosquitoes. There are no other commercially available bacterial pathogens for the management of other vector populations (e.g. Yellowjackets, rodents, and ticks).

Examples of bacteria pathogenic to mosquitoes are *Bacillus sphaericus* (Bs), the several strains of *Bacillus thuringiensis israelensis* (Bti), and *Saacharopolyspora spinosa*. Two bacteria, Bs and Bti, produce proteins that are toxic to most mosquito larvae, while *Saccharopolyspora spinosa* produces compounds known as spinosysns, which effectively control all larval mosquitoes. Bs can reproduce in natural settings for some time following release. Bti materials applied by the District do not contain live organisms, but only spores made up of specific protein molecules.

2.6.3 Applicable to District IVMP

Bti and Bs are already used under current Program. *Saccharopolyspora spinosa* is under consideration and may be used in the future.

Bacillus sphaericus is a commonly occurring spore-forming bacterium found throughout the world in soil and aquatic environments. Certain strains of this bacterium produce a protein endotoxin, which is pathogenic to immature mosquitoes. This endotoxin destroys the insect's gut in a way similar to the protein crystals of *Bacillus thuringiensis* var. *israelensis* (Bti). That is, the toxin is only active against feeding mosquito larval stages and it must be partially digested before it becomes activated.

B. sphaericus adversely affects larval mosquitoes but, in contrast to Bti, is virtually nontoxic to Black Flies (Simuliidae). *Culex* species are the most sensitive to *Bacillus sphaericus*, followed by *Anopheles* and some *Aedes* species. In California, *Culex* spp. and *Anopheles* spp. may be effectively controlled. Several species of *Aedes* have shown little or no susceptibility, and salt marsh *Aedes* are not susceptible. *B. sphaericus* differs from Bti in being able to control mosquito larvae in highly organic aquatic environments, including sewage waste lagoons, animal waste ponds, and septic ditches. Also, in contrast to Bti, field evaluations of commercial *B. sphaericus* products (VectoLex) have shown environmental persistence for 2-4 weeks, and the ability to recycle (grow and reproduce). This persistence varies with a number of environmental parameters, and is low in saline or highly organic environments.

B. sphaericus has been extensively tested and has had no adverse effects on mammals or other nontarget organisms (Ali and Nayar, 1986; Aly and Mulla, 1987; Aly et al., 1985; Holck and Meek, 1987; Karch et al., 1990; Key and Scott, 1992; Lacey and Merritt, 2003; Merritt et a.l, 2005; Miura et al., 1981; Mulla et al., 1984; Rodcharoen et al., 1991; Shadduck et al., 1980; Siegel and Shadduck, 1990; Tietze et al., 1993; Walton and Mulla, 1991; Yousten et al., 1991). No mortalities, pathogenicity or treatment-related evidence of toxicological effects were observed in rats administered oral, intravenous or intratracheal doses of technical *B. sphaericus*. The acute oral and dermal LD_{50} values are greater than 5,000 mg/kg and 2,000 mg/kg respectively. Oral exposure of *B. sphaericus* is practically nontoxic to mallard ducks. No mortalities or signs of toxicity occurred following a 9,000 mg/kg oral treatment. Birds fed diets containing 20 percent w/w of the technical material experienced no apparent pathogenic or toxic effects during a 30-day treatment period. Mallards given an intraperitoneal injection of *B. sphaericus* demonstrated toxicological effects including hypoactivity, tremors, ataxia and emaciation. The LD_{50} value was greater than 1.5 mg/kg.

Acute aquatic fresh water organism toxicity tests were conducted on bluegill sunfish, rainbow trout and daphnids. The 96-hour LC_{50} and NOEC (No Observable Effect Concentration) value for bluegill sunfish and rainbow trout was greater than 15.5 mg/liter; the 48-hour EC_{50} and NOEC value for daphnids was greater than 15.5 mg/liter. Acute aquatic saltwater organism toxicity tests were conducted on sheepshead minnows, shrimp and oysters. The 96-hour LC_{50} value for both sheepshead minnows and shrimp was 71 mg/liter, while the NOEC value was 22 mg/liter for sheepshead minnows and 50 mg/liter for shrimp. The 96-hour EC_{50} value for oysters was 42 mg/liter with a NOEC of 15 mg/liter. The LC_{50} and NOEC value for immature mayflies was 15.5 mg/liter. Honeybees exposed to 10^{-4} to 10^{-8} spores /ml for up to 28 days demonstrated no significant decrease in survival when compared to controls. Additional studies on various microorganisms and invertebrates, specifically cladocerans, copepods, ostracods, mayflies, chironomid midges, water beetles, backswimmers, water boatmen, giant water bugs, and crawfish, have shown no adverse effects or negative impacts. Furthermore, Ali (1991) states that although *B. sphaericus* is known to be highly toxic to mosquito larvae, *B. sphaericus* does not offer any potential for midge control. Acute toxicity of *B. sphaericus* to nontarget plants was also evaluated in green algae. The 120-hour EC_{50} and NOEC values exceeded 212 mg/liter.

Lacey (2007) reviews the prior 20 years of research concerning *B. sphaericus* toxins, their modes of action and factors affecting activity, resistance, safety, and the role of this entomopathogen in integrated mosquito management programs. He concludes that in many situations this bacterial biological control

agent of mosquitoes is an effective alternative to many other broad spectrum mosquito larvicides as it has numerous environmental benefits including safety to nontarget organisms, reduction of pesticide residues, no effect on the activity of other mosquito predators and pathogens, and little or no overall environmental impact. The compatibility of this insecticide with other biological control agents also allows for a more sustainable integrated management approach and it is the cumulative effect of the aforementioned advantages that help to offset the significant increases in costs associated with the use of this insecticide. The one concern is resistance, especially since the *B. spahericus* toxin apparently binds to a single receptor on the microvilli of the larval midgut. Resistance has been reported in a number of regions throughout the world (Adak et al., 1995; Chevillon et al., 2001; Mulla et al., 2003; Nielsen-LeRoux et al., 2002; Oliveira et al., 2003, 2004; Rao et al., 1995; Silva-Filha et al., 1995; Su and Mulla, 2004; Wirth et al., 2000). Therefore, this material must be used with care and routinely rotated with the use of other available insecticides (e.g. Bti) and management strategies to minimize the risk of resistance (Regis and Nielsen-LeRoux, 2000; Zahiri et al., 2002).

2.7 Biological Control Parasites

2.7.1 Description

The life cycles of mosquito parasites are biologically more complex than those of mosquito pathogens and involve intermediate hosts, organisms other than mosquitoes. Mosquito parasites are ingested by the feeding larva or actively penetrate the larval cuticle to gain access to the host interior. Once inside the host, parasites consume the internal organs and food reserves until the parasite's developmental process is complete. The host is killed when the parasite reaches maturity and leaves the host (*Romanomermis culicivorax*) or reproduces (*Lagenidium giganteum*). Once free of the host, the parasite can remain dormant in the environment until it can begin its developmental cycle in another host.

2.7.2 Examples of Tool Use

Examples of mosquito parasites are the fungi *Coelomomyces spp*., *Lagenidium giganteum, Culicinomyces clavosporus*, and *Metarhizium anisopliae*; the protozoa *Nosema algerae, Hazardia milleh, Vavraia culicis, Helicosporidium* spp*., Amblyospora californica, Lambornella clarki*, and *Tetrahymena* spp.; and the nematode *Romanomermis culicivorax*.

> ***Lagenidium giganteum*:** *Lagenidium giganteum*, an oomycete fungus, was briefly available under the trade name Laginex. Production, storage (long shelf life), registration, and costs were some of the issues limiting the use of this parasite for mosquito control. Other factors included the environmental limitations of temperature (less than 16 or more than 32°C), moderate salinity levels (less than 10 ppt) and moderate organic content of the water (Kerwin, 2007, Merriam and Axtel, 1982). Scholte et al. (2004) reviews the different entomopathogenic fungi that have been studied for mosquito control purposes and states there are nine key features of an ideal fungus for mosquito control. These are:

- kills adult and larval stages,
- requires no more than a few applications per season,
- is easily dispersed by adult female mosquitoes to uninfected breeding sites,
- shows residual activity and persistence in mosquito populations after introduction,
- kills only mosquitoes,
- is effective over a wide range of salinity, temperature, humidity, and water quality conditions,
- is easily and cost-effectively mass produced,
- has a long shelf-life and can be easily stored, and
- is not harmful to humans or other nontarget organisms.

Scholte concludes by stating that “none of the mosquito-pathogenic fungi presently known exhibit all of these characteristics, but they all exhibit at least some.”

> **Other Fungi:** Other fungi, including the recently reclassified microsporidia, continue to be found and studied for their potential as biological control agents. Andreadis (2007) and Scholte et al. (2004) provide thorough updated reviews of the entomopathogenic fungi of mosquitoes. Elucidation of their complex life histories and effectiveness as biological control agents of mosquitoes (e.g. *Coelomomyces* spp., *Culicinomyces* spp. and certain microsporidia) are discussed. As mentioned above there are still some technical issues to be solved before these biological control agents could be commercially produced and available for use.

> ***Lambornella clarkii*:** *Lambornella clarki*, has been studied as a biological control agent of container breeding mosquitoes, especially the Western Treehole Mosquito, a natural host of this endoparasitic ciliate (Washburn and Anderson, 1986, 1990a, 1990b; Washburn et al., 1988). This parasite has cysts, which are resistant to desiccation and, therefore, allow this ciliate to persist to the next year. Production and storage methods investigations, and early field trials have been conducted to determine the efficacy of this ciliate for biological control (Anderson et al., 1986a, 1986b, 1989; Anderson and Washburn 1989a, 1989b, 1990). Although the data demonstrates that L. clarki appears to be a promising biological control agent, it is at this time not commercially available for use.

> **Nematodes:** Mermithid nematodes, especially *Romanomermis* spp. and *Reesimermis* spp., have received a fair amount of study for use as biological control agents of mosquitoes, with *Romanomermis culicivorax* having been commercially produced as Skeeter Doom for a short time many years ago. Although this nematode showed much promise there were still the following limitations restricting its widespread use: low salinity levels, organically rich waters with low oxygen levels, predation by other aquatic organisms, the potential for the development of host resistance, and the costs associated with mass in-vivo production (Legner, 1995; Peterson, 1978; Peterson and Willis, 1970; Platzer, 2007; Platzer, 1981).

2.7.3 Applicable to District IVMP

These parasites are not generally available commercially for mosquito control at present. The District does not currently use mosquito parasites in its mosquito control program.

2.8 Biological Control Predators

2.8.1 Description

Mosquito predators are represented by highly complex organisms, such as insects, fish, birds, and bats that consume larval or adult mosquitoes as prey. Predators are opportunistic in their feeding habits and typically forage on a variety of prey types, which allows them to build and maintain populations at levels sufficient to control mosquitoes, even when mosquitoes are scarce.

The ability of predators to control mosquitoes is related to four factors: 1) whether mosquitoes are preferred prey, 2) whether the hunting strategy of the predator maximizes contact with mosquitoes, 3) whether the predator consumes large numbers of mosquitoes, and 4) whether the predator is present in sufficient numbers to control mosquitoes. Predator effectiveness is enhanced when proper conditions are present.

The District recognizes the value of maintaining and promoting as many native predatory species as possible in mosquito breeding habitats, as this helps to reduce the use of pesticides as well as human-vector interactions and associated health issues.

2.8.2 Examples of Tool Use

Predators as discussed in this section are, therefore, loosely grouped into five general categories: invertebrates, amphibians, fish, bats and birds.

Only mosquitofish are commercially available to use at present. The District supports the presence of the other predatory species when this proves practical. The District's practice of rearing and stocking of mosquitofish in mosquito habitat reflects the most commonly used biological control agent for mosquitoes in the world. The fish are stocked only in water features such as ponds, closed ornamental ponds or horse troughs and care is taken to ensure that they cannot gain access to waters of the state or waters of the U.S.

2.8.2.1 Invertebrates

These are the most numerous and commonly encountered predators of mosquitoes within any mosquito breeding habitat. Their members include but are not limited to: coelenterates; platyhelminths (flatworms); cyclopoid copepods; insects of many orders, especially *Odonata* (Dragonflies and Damselflies), *Ephemeroptera* (Mayflies), *Hemiptera* (the True Bugs), *Coleoptera* (Beetles); and spiders. A resurgence of research and evaluation on the various invertebrate predators of immature mosquitoes began in the late 1960s and has continued to this day (Ali and Mulla, 1983; Bay, 1969, 1967; Collins and Washino, 1978; Ellis and Borden, 1970; Garcia and Schlinger, 1970; Garcia et al., 1974; Hazelrigg, 1974; Hokama and Washino, 1966; Lee, 1967; Legner and Medved, 1970, 1974; Miura et al., 1978; Qureshi and Bay, 1969; Rayah, 1975; Robert et al., 1967; Sjogren and Legner, 1974; Stewart and Miura, 1978; Veneski and Washino, 1970; Washino, 1969a, 1969b; Yu and Legner, 1975; Yu et al., 1974; Zalom et al., 1978). Factors, such as, effectiveness, culture techniques and release, as well as potential environmental limitations of salinity, temperature, pH, presence/lack of vegetation, substrates, seasonality of flooding and drying of habitats, persistence, and prey selectivity have been examined for a number of mosquito predators.

Quiroz-Martinez and Rodriguez-Castro (2007) provide a nice summary of the use of aquatic insects as predators of immature mosquitoes. Their discussion includes a review of the factors significant to the success of biological control programs for mosquitoes, especially with respect to the predator-prey relationship. These factors are:

> prey preference of the predator,

> species diversity within the mosquito habitat,

> aquatic ecosystem stability,

> density of the larval mosquito population,

> where the predator typically spends most of its time within the water column;

> number of predators needed for release and optimal efficacy,

> recovery of the immature mosquito population,

> predator-prey synchronization,

> refugia for both the predator and especially the prey,

> coevolution of the antipredation responses of the prey and the attack processes of the predator, and

> community participation in both the planning and operational efforts to help the community understand the roles various biocontrol organisms play in controlling mosquitoes.

Mogi (2007) elaborates further on some of the challenges associated with the use of invertebrate predators. First, is the issue of mass production, storage and release, especially since most predators are cannibalistic and also require live organisms as a food source. Second, many are opportunistic in their predatory habits and consume a wide variety of prey other than mosquitoes. This can be helpful as it

allows predators to survive when mosquito populations are low or altogether absent. Conversely, it can be a disadvantage because predators may not effectively reduce mosquitoes due to the availability of alternative prey; some of which include populations of other beneficial mosquito predators. Third, is the presence of other indigenous predators and the complexity of the relationships and differences in vulnerabilities that exist not only between predator-prey but also amongst the different predator populations within a given ecosystem. Anti-predator behaviors, chemical cues and other types of interference are not fully understood; and more research is required to better understand what factors contribute to predator effectiveness.

Marten and Reid (2007) provide a good review of the research concerning cyclopoid copepod biology, mass production, storage, field application, and environmental and health impacts. It is important to note that copepods cannot be utilized in all habitats and therefore must be matched to the appropriate mosquito breeding site to be effective. Equally important, cyclopoid copepods effectively reduce *Aedes* mosquitoes, but are less effective at reducing *Anopheles* spp. and *Culex* spp. mosquito populations. Depending on the species of copepod being utilized, other factors that can affect their use include desiccation, temperature, the presence of heavy metals, and chlorine.

Legner (1995) includes a review of the research and current knowledge concerning the use of platyhelminth (flatworms) for the biological control of mosquitoes. The advantages of their use include ease of mass production, tolerance to environmental contaminants, their ability to reproduce quickly following introduction, excellent predatory behavior in shallow water habitats with emergent vegetation, and their ability to overwinter. Conversely, the disadvantages include the requirement that mass culture be continuous and requires the need for highly trained technical staff, and that the persistence of flatworms in the field depends on the presence of adequate alternative food resources when immature mosquito populations are low.

2.8.2.2 Amphibians

Amphibians are known predators of a number of aquatic organisms including mosquitoes. Diet studies of newts, salamanders, frogs and toads indicate that they are opportunistic generalist predators preying upon various arthropods such as cladocerans, ostracods, insects, spiders and small crayfish, as well as snails, slugs, oligochaete worms, planaria, and the occasional small vertebrate such as fish or other immature amphibians (Anderson, 1968; Avery, 1968, Blum et al., 1997; Brophy, 1980; Bruggers, 1973; Clarke, 1974; Dodson and Dodson, 1971; Freda, 1983; Frost, 1935; Fulk and Whitaker, 1969; Hayes and Tennant, 1985; Hamilton, 1940; Korschgen and Moyle, 1955; Taylor et al., 1988). Although arthropods make up a significant portion of most amphibian diets, mosquitoes appear to be insignificant as a prey item.

Specific studies and data addressing the role and/or use of amphibians as a viable and effective tool for the control of mosquitoes is limited. Howard (1901) reports on the preliminary work of a Mr. Albert Koebele who recounted the use of salamanders that were imported from California to Hawaii. Although not a formal published study, this is one of the earliest records of attempting to use amphibians to help manage mosquito populations. Barber and King (1927) recounts observations and subsequent experiments with the tadpoles of Hammond's Spadefoot Toad (*Scaphiopus hammondii*) in New Mexico that were found to consume crustaceans and mosquito larvae. He concluded that although the tadpoles consumed mosquito larvae the short active season of the toad, the restriction of its habitat to temporary pools, and its lower larval consumption efficiency compared to larvivorous fishes limited its usefulness. Matheson and Hinman (1929) examined the gut contents of 59 Vermilion Spotted Newts and noted that 47 of them contained an average of eight or more mosquito larvae per newt. Other prey items consumed included cladocerans, ostracods, copepods, phyllopods and an occasional aquatic insect. Feeding studies in the lab utilizing battery jars indicated these newts were efficient predators of mosquito larvae and that when provided alternative prey preferred mosquito larvae. Matheson and Hinman were also careful to point out that in their gut content studies they did not carefully assess the full extent of the other prey items found. Spielman and Sullivan (1974) worked with tadpoles of the Giant Tree Frog *Hyla*

septentrionalis on Grand Bahama Island and suggested that the presence of frogs seemed to limit the abundance of the Southern Little House Mosquito, *Culex pipiens quinquefasciatus,* in certain manmade container habitats. Their lab studies utilizing enamel pans indicated that the tadpoles would consume mosquito larvae, especially the earlier instars, although the tadpoles did not actively pursue the larvae nor did the pans accurately reflect natural environmental conditions (e.g. other predator prey relationships that might occur as well as the presence of significant numbers of alternative prey items for the tadpoles). In large artificial containers such as 55-gallon drums and cisterns, they found tadpoles effectively controlled *Culex pipiens quinquefasciatus*. Therefore, they concluded from their lab studies, field observations of mosquito habitats with and without tadpoles, and the fact that immature mosquitoes were usually absent or in very low numbers when tadpoles were present that *Hyla septentrionalis* immatures "denied certain breeding sites to *Culex pipiens quinquefasciatus*." Freed (1980) examined prey selection, activity, and size with the Green Tree Frog *Hyla cinerea* in the lab and found that this frog consistently selected houseflies over four different mosquito species. Prey size was found to be insignificant as a determining factor for selection. Difficulty of prey capture and prey activity were significant with prey item activity being a factor in determining prey selection. Ritchie (1982) also worked with *Hyla cinerea* noting that tadpoles consumed *Culex nigripalpus* mosquito larvae and suggested that *H. cinerea* could play a significant role in the natural control of some mosquitoes in Florida. Blum, Basedow and Becker (1997) performed a 3-year field study of the Rhine Valley in Germany, examining the stomach contents of 2,163 anurans and found an average of 7.7 prey items per stomach with 0.16 percent consisting of mosquitoes. They concluded from their observations that the impact of anurans on mosquitoes would be negligible and furthermore that biological mosquito control with Bti would not negatively impact the diet of anurans. Brodman et al. (2003) worked with Blue Spotted and Tiger Salamanders in both natural wetlands and artificially created mesocosms to assess their effects on aquatic invertebrate and larval mosquito densities. They found the data from the mesocosms was consistent with what they observed in the field and that overall densities of mosquito larvae in mesocosms with salamanders was 91 to 94 percent lower than those without salamanders. Therefore, the larvae of pond breeding salamanders have the potential to control mosquitoes that utilize temporary wetlands. Lab studies by Willems et al. (2005) with four species of common Australian frogs found that although the tadpoles consumed some mosquito larvae, they did not consume substantial numbers and therefore were not effective predators of mosquito larvae. They suggested that alternate food preferences and the lack of active prey searching limited their effectiveness as biological control agents. Brodman and Dorton (2006) examined the gut contents of 42 field-collected tiger salamanders in Indiana and found that 93 percent of all prey items observed were cladocerans and ostracods and were present in 36 percent of the stomachs dissected. Mosquitoes were found in 26 percent of the stomachs examined and comprised 1.67 percent of all prey items collected and identified from the 42 stomachs. In lab experiments, they found Tiger Salamander larvae could consume an average of 144 mosquito larvae per day and postulated by extension that a population of 8,000 salamander larvae could consume over 1,000,000 mosquitoes per day. Although possible, this did not take into account a number of factors such as presence, abundance, availability, and seasonality of alternative prey, nor the fact that wetlands and the interactions of the organisms that reside within them are quite complex and do not readily lend themselves to such broad generalizations. Their suggestion that Tiger Salamander larvae could naturally reduce immature mosquito populations in wetlands seems possible, although the stomach content analysis would indicate mosquito larvae are a small portion of their overall diet. DuRant and Hopkins (2008) performed feeding experiments with Red-Spotted Newts, Mole Salamanders and the mosquitofish *Gambusia holbrooki*. Both the newt and the salamander readily consumed more than 300 mosquito larvae per day suggesting that these amphibians could have an impact on larval mosquito populations. The study also recognized that only a single prey item, mosquito larvae, was utilized and therefore did not account for the influence of invertebrate community composition in a natural setting on overall larval mosquito consumption rates of salamanders and newts.

A review article by Rhagavendra et al. (2008) summarizes the current knowledge concerning the use of frogs for the biological control of mosquitoes. Their review notes the limited number of studies available

and numerous information gaps. They also point out the need for ecological investigations that help clarify the interactions, connections and predator-prey relationships between frogs, mosquitoes and other wetland organisms to better determine and understand the possible role of frogs as biological control agents of mosquitoes. These same concerns can also be said for salamanders, newts and toads whose broad diets include, albeit on a limited scale, mosquitoes.

Some additional areas of concern when considering the use of amphibians as a biological control agent include but are not limited to:

> their inability to be utilized in all types mosquito breeding habitats (e.g. saline tidal marshes, wastewater ponds, sewage lagoons, winery waste ponds, septic tanks, storm drains, etc.);

> what the ecosystem effects would be of introducing or mass releasing amphibians into new or nonnatural areas;

> the ability to rear and quickly introduce large numbers of amphibians to various locations throughout the county; and

> potential concerns by some members of the public about the sudden appearance of "large numbers" of frogs or salamanders in their yards that could also get into their homes, and/or the "noise" created by large numbers of frogs in their yards at night.

Although amphibians feed on a wide variety of prey items, including mosquitoes, the current knowledge and understanding indicates they have a minimal effect on mosquito populations. The District does however emphasize the recognition and importance of amphibians within any mosquito-breeding habitat with its staff and also makes every effort to promote the continued presence and well-being of amphibians while engaging in vector management activities.

2.8.2.3 Fish

The recommendation that certain species of fish were useful biological control agents of mosquitoes dates back to the earliest control work with mosquitoes (Felt, 1904; Hildebrand, 1921; Howard, 1901; Howard et al., 1912; Hardenburg, 1922; Hubbs, 1919; Kennedy, 1916; Rockefeller Foundation, 1924; Scofield, 1915; Smith, 1904; Stead, 1907). There are a number of fish that have been studied as potential immature mosquito predators. Walton (2007), Legner (1995), and Downs (1991) discuss the use and limitations of mosquitofish (*Gambusia* spp.) as well as other fish species that have received considerable attention as potential biological control agents of immature mosquitoes. Examples of other fishes studied include but are not limited to: the Three-Spine Stickleback (*Gasterosteus aculeatus*), Common Guppy (*Poecilia reticulata*), Pupfish (*Cyprinodon* spp.), Goldfish (*Crassius auratus*), Tilapia (*Tilapia zilli*), Green Sunfish (*Lepomis cyanellus*), and Inland Silversides (*Menidia beryllina*). These and other species have been examined and in many instances found to be of limited use, not as effective as mosquitofish, or as in the cases of some fish taxa they tend to out compete the native fauna and/or are nonnatives whose use is restricted or not allowed.

Only the mosquitofish (*Gambusia affinis* and *Gambusia holbrooki*) are commercially available for use at present, with *G. affinis* being the species typically utilized in the Western United States. Both species are very similar in behavior, biology and habits and therefore the term mosquitofish as used here will apply to both. It has been presumed that both species are present within California (Dill and Cordone, 1997) and may even exist within the Program area. Therefore, this review will encompass literature and data for both species.

A thorough review of *Gambusia affinis* and *G*. *holbrooki* biology, emphasizing information concerning physiology, growth, development, reproduction, courtship, mating, foraging behavior, diet, dispersal and movement patterns, physical and chemical tolerances, and ecosystem and interspecific interactions is provided by Johnson (2008), Pyke (2008, 2005) and Swanson et al. (1996). Mosquitofish in general are quite tolerant of a wide range of environmental conditions. This feature when combined with their surface

feeding habits, ability to reproduce quickly, ease of transport, and sustainability in small volumes of water makes them ideally suited as a biological control agent of immature mosquitoes when utilized in carefully selected, isolated aquatic habitats (e.g. neglected residential swimming pools, ornamental ponds, water gardens, large fountains, animal troughs, etc.).

Mosquitofish, despite their name, cannot survive solely on a diet of mosquito larvae (Reddy and Pandian, 1972). Laboratory and field studies have shown that mosquitofish are opportunistic omnivores that consume a wide variety of prey items, including algae, zooplankton, copepods, cladocerans, and immature stages of many insects, including but not limited to midges, water beetles, water boatmen, damselflies and mayflies (Ahmed et al., 1970; Barnickol, 1941; Bence, 1988; Erguden, 2013; Farley, 1980; Garcia-Berthou, 1999; Gkenas et al., 2012; Hess and Tarzwell, 1942; Hildebrand, 1921; Lawler et al., 1999; Mansfield and Mcardle, 1998; Miura et al., 1979; Pen and Potter, 1991; Reed and Hoy, 1970; Rice, 1941; Walters and Legner, 1980; Walton and Mulla, 1991; Washino and Hokama, 1967). The research of Hess and Tarzwell (1942) concluded that mosquitofish were true opportunistic feeders, so that the simple availability of prey was the key criterion in prey selection by mosquitofish. As such, the selection of food items by mosquitofish apparently shifts away from specific prey as its abundance drops.

Within their generally wide diet, mosquitofish do have some clear feeding preferences, including food at the water surface, prey size ranging from large zooplankton to very small fish or invertebrates, and prey that does not have highly effective escape behaviors (Swanson et al., 1996). While their feeding preferences, ability to rapidly reproduce and colonize a habitat, and ease of transport make these fish useful for mosquito control purposes, their use has also generated questions concerning their potential, impacts to native fauna and sensitive ecological systems. This has resulted in an extensive body of research attempting to address these questions.

Views vary widely with respect to the benefits and adverse environmental impacts of mosquitofish as a biological control agent for mosquito control programs. Rupp (1996) examined 59 years of literature that contained statements pointing out the concerns of ichthyologists and some researchers about the ineffectiveness as a predator as well as the nontarget impacts to native biota of mosquitofish. Indeed, there can be circumstances when the generalist predatory nature of mosquitofish would make this biocontrol agent either ineffective or inappropriate to use. As with any tool utilized for the management of mosquitoes, proper use and placement is everything. Indiscriminate placement without regard for recognizing the sensitive nature of habitats, the diversity and density of potential prey items present at the site, the use of too few or too many fish for the size of the area, an understanding of the historical and present mosquito population dynamics, the potential for unintended relocation from the placement site, the seasonality of flooding and drying, density of vegetation, water quality, and behavior and habitat use of the species of mosquito being managed are but a few of the factors that can render mosquitofish ineffective and even a potential problem for sensitive native organisms.

Rowe et al. (2008) performed an exhaustive review of the biology, behavior and impacts of a number of invasive fishes in Australia, including the mosquitofish. Their report to the Australian government summarized the results of more than 40 studies that had been conducted through part of 2007 concerning the impacts of *Gambusia holbrooki* to native Australian amphibians and fishes. Their review also included some of the studies conducted in the United States and New Zealand concerning zooplankton and other invertebrates as well as aquatic vertebrates. This report classified the impact studies into four types:

> correlative, using field studies on distribution and relative abundance to provide evidence that a native species may have been impacted where an introduced species now occurs;

> impact assessments based on field studies which utilize information of biology and ecology to predict the feasibility of species interactions, or tank studies which examine the likelihood of certain interactions under controlled laboratory conditions;

> impact assessments in the field that demonstrate the existence of impact mechanisms in the wild; and

> species manipulations (removal of the invasive) in the field to determine if native species recover.

They are careful to point out the shortcomings of each study type on their own and that it is the combination of all four, which is necessary to better understand what types and range of ecosystem impacts truly are associated with the introduction of a nonnative organism. Their conclusions concerning mosquitofish are as follows:

> irrefutable proof of the impact of *Gambusia* is lacking although there are a number of studies that provide some evidence of impacts on native fishes and amphibians;

> that evidence from these studies indicate that this fish can create ecological issues through a reduction in native species diversity in some areas and not in others; and

> the ecological impact of *Gambusia* is affected by other environmental factors (e.g. temporal, spatial, weather, human induced) which vary in intensity from location to location.

The complexity of interactions between organisms within an ecosystem, and for that matter the dynamics of any given ecosystem, presents many challenges when attempting to assess and understand the many biotic and abiotic inter- and intra-relationships that exist; and Rowe and coworkers plainly state this concern while reviewing the body of literature on the impacts of introduced fishes in Australia. Pyke (2008) also reviewed mosquitofish biology, ecology and the impacts of these fish and included in his discussion concerns about trophic level effects as well as the management issues of mosquito control and wildlife management.

A study not mentioned by Rowe but of interest is that of Goodsell and Kats (1999). They performed as a part of their research a gut content analysis of 36 stream collected *G. affinis* and found Pacific Treefrog tadpoles in 65 percent of the stomachs. This is unusual as there appear to be no other gut content studies that have been reported with mosquitofish that co-existed with amphibians. Their laboratory and field experiments also showed that mosquitofish preyed upon tree frog tadpoles even when high densities of mosquito larvae were given as alternate prey.

Mosquitofish impact studies on frogs and fish since Rowe et al. (2008), as well as all research on other organisms also neatly fits into their categorization system of correlative, two types of impact assessment and, invasive species manipulations or removal. Most of the research continues to be either correlative or impact assessments that demonstrate the likelihood of certain interactions under controlled laboratory conditions. The remaining discussion will review research on frogs and fish since Rowe and coworkers report and then review the research both before and after Rowe for other amphibians and wetland organisms.

The interactions between mosquitofish and frogs has begun to receive more attention with the increased awareness that most research had been focused on mosquitofish interactions with native fishes. Gregoire and Gunzberger (2008) utilized tanks in the lab to assess the effects of three species of predatory fish, including *Gambusia holbrooki*, on the survival and behavior of the Southern Leopard Frog and the Gopher Frog. Their observations noted that mosquitofish did injure the frog tadpoles and that this increased tadpole hiding behavior. They suggested that the introduction of predatory fish could negatively affect frog populations especially in normally fish-free wetlands. It should be noted that this study did not provide alternative prey and therefore focused strictly on the interactions between the fish and frog tadpoles contained within 10-gallon aquaria. Karraker et al. (2011 **[Ref list has 2010]**) worked with four species of frogs and one toad from the lowland wetlands of southern China and noted that the four species of frog tadpoles were susceptible to predation. They also suggested that the other frog species present within the Chinese lowland wetlands may be subject to predation and therefore further investigation and potential conservation measures should be taken. It is of interest to note that predation testing in this study occurred in small containers, and no form of refugia was provided for the tadpoles. Stanback (2008 **[Ref list has 2010]**) observed the interaction of hatchling tadpoles of the Upland Chorus frog, *Pseudacris feriarum*, and

mosquitofish in 100-gallon cattle tanks. Those tanks with fish had no tadpoles remaining while the tadpole only tanks had approximately 10 percent of the introduced tadpoles still present. He suggested that *Gambusia* were highly effective predators of hatchling tadpoles, even on frogs that have co-evolved with this fish. This particular study does have some issues though. First, there was a high density of fish placed into the tanks. Second, there was no assessment concerning the presence or abundance of alternative prey. Third, as Stanback pointed out, the potential for tadpole cannibalism was not taken into account.

The study by Shulse et al. (2013) is different from most prior research in that they examined mosquitofish and the development of community structure over a 4-year period in constructed experimental wetlands. They found that the introduction of mosquitofish reduced the abundance of two species of Grey Treefrogs (*Hyla versicolor* and *H. chrysoscelis*), the Boreal Chorus Frog (*Pseudacris maculata*), and aquatic invertebrates. They also noted that mosquitofish had no significant effect on the Green Frog, *Lithobates clamitans.* When mosquitofish were removed, invertebrate abundance increased; and they suggested that mosquitofish removal may have also been a contributing factor in Chorus Frog recolonization of the experimental wetlands with low invertebrate predator abundance. From their observations, they suggested that mosquitofish were detrimental to wetland communities and recommended against their future use.

Reynolds (2009) performed a gut content, field correlative and lab controlled species interactive study and essentially found there was minimal impact when assessing the effect of *Gambusia holbrooki* on six species of amphibians in Southwestern Australia. His study noted that the gut contents of 48 fish collected from five wetland sites where frogs occurred showed no evidence of frog eggs or tadpoles. Furthermore, in laboratory feeding trials, *Gambusia* that had not fed for four days did not consume the eggs of any of the frog species worked with in the lab but did consume alternate invertebrate prey at the end of the egg palatability trials. Unfortunately, trials with tadpole hatchlings for all but one species and the older tadpoles of one frog species did result in a mosquitofish feeding response. Reynolds also surveyed 25 wetland sites and found *Gambusia* at 20 of the sites, frogs at all 25 sites, and that the combination of all frog species co-existed with fish at more than eight of the sites. Most importantly, he noted that frog species richness did not differ between sites with and without mosquitofish. He concluded that "in contrast to the situation in eastern Australia, populations of anuran species in southwestern Australia do not appear to be strongly affected by this small invasive fish." It was further suggested that other factors such as frog egg deposition site, breeding time of the frogs, availability and abundance of alternative prey, condition of the wetland, and temporal variation in fish abundance and size may influence the impact of mosquitofish on frogs. Bottom line, the interactions of mosquitofish and amphibians is a complex issue and requires careful consideration and analysis in light of the many studies completed to this point in time.

Two additional studies of note are those of O'Meara and Darcovich (2008) and Alvarez et al. (2004), both of which report changes in frog populations following the removal of nonnative fish. Alvarez et al. (2004) surveyed 90 managed stock ponds within the Kellogg Creek Watershed (Contra Costa County, CA) and noted seven ponds with exotic fish, four of which also had mosquitofish, and that these ponds had little use as well as almost no reproduction by Red-Legged Frogs. Two of the ponds in particular only had large populations of mosquitofish. When the fish were removed, frog use and reproduction improved. O'Meara and Darcovich (2008) report the increase of Green and Golden Bell frogs following the rotational drainage and subsequent removal of mosquitofish from ponds in a wetland park that had 22 habitat ponds constructed for the frog. Over a period of three years, a different set of ponds, or about one third of the 22 ponds, were drained and allowed to remain dry for a period of four weeks. Ponds were then refilled and monitored. Although fish and frogs did coexist, frog numbers, especially tadpoles and juveniles, improved with the reduced presence of mosquitofish. Additionally, sightings of adult frogs were significantly improved and had reached their highest levels on record since construction of the wetland in 2000 in 2004–2005 and again in 2005–2006. It should be noted that fish did reinvade many of the ponds within a few months of draining, and data concerning tadpole numbers post fish recolonization is not

clearly presented. There is also a lack of data concerning the presence and abundance of other potential predators of these frogs with the exception of a passing reference to a predatory eel.

The more recent impact studies concerning native fish are varied both in scope and design although there is one that attempted to assess the removal of mosquitofish in the field to determine if native species would recover. Laha and Mattingly (2007) observed the interaction between *Gambusia affinis* and the Barrens Topminnow, *Fundulus julisia* in small glass tanks in the lab. They noted that for short-term exposures, juvenile topminnows were quite vulnerable to aggression and predation, which they attributed to mosquitofish. A 60-day interaction study with the adults of both species yielded no negative effects with the exception of fin injury to top minnows that were syntopic with mosquitofish. From their observations, they suggested that the impacts of mosquitofish on Barrens Topminnows was primarily through predation and injury to the early life stages. Laha and Mattingly also pointed out the limitations of their experimental design, specifically that not all dimensions of the natural environment could be adequately represented. Keller and Brown (2008) examined the behavioral interactions that occurred between allopatric and sympatric populations of wild caught *Gambusia holbrooki* and the native Australian Ornate Rainbow fish, *Rhadinocentrus ornatus* in laboratory maintained aquaria and from their observations suggested that mosquitofish presence and aggression was responsible for the behavioral and microhabitat shifts that occurred with the Rainbow fish. They noted that Rainbow fish individuals from allopatric populations were more susceptible to fin nipping and being chased than their sympatric counterparts, that sympatric Rainbow fish had shifted their microhabitat preferences (thus allowing them to coexist with mosquitofish) and also exhibited a greater level of aggression during all stages of mosquitofish exposure. MacDonald et al. (2012) performed a quantitative survey of 93 wetlands in Southeastern Australia in an effort to develop a model of the influence of *Gambusia holbrooki* on native fish species diversity, abundance and physical condition. From their findings, they asserted that *Gambusia holbrooki* exerted a strong effect on the likelihood of wetlands being occupied by most other species of fishes and that their level and direction of influence on the presence, abundance and/or physical condition of different fish taxa seemed dependent on both biotic and abiotic factors. It was also observed that three species of native fishes, Australian Smelt, Flat-Headed Gudgeon and Carp-Gudgeon, co-existed with mosquitofish in wetlands without aquatic vegetation and both species of Gudgeon juveniles showed no strong evidence of fin damage. Therefore, they proposed that some generalist life history strategies may insulate certain native fish species allowing them to successfully coexist with mosquitofish. Tonkin et al. (2013 **[Ref list has 2014]**) performed a field based study, utilizing 13 wetland sites, to assess the effects of mosquitofish removal on wetland fishes. Like MacDonald et al. (2012), a predictive modeling approach was used and overall it was found that there was no response by three species of fish, the Carp Gudgeon, Australian Smelt and the Common Carp, to removal of mosquitofish. It was suggested that the limited duration of the study and number of sites, and possibly even the species used, may have played a role in not being able to detect an impact of *Gambusia* on the rate of population change for any of the three species of fish being observed. However, the authors did conclude that their data supported the earlier findings of MacDonald et al. (2012) that suggested the direction and level of impact of mosquitofish on wetland fish species was quite fluid and dependent on biotic and abiotic influences. It was also suggested that those organisms with more flexible life-history strategies are more able to coexist with mosquitofish than those, which have more an overlap in time, diet and habitat.

Other studies with mosquitofish suggest they may impact some species of native salamanders and newts, aquatic invertebrate populations and planktonic communities. Gamradt and Kats (1996) surveyed 10 streams in the Santa Monica Mountains of southern California in 1994 and 1995 and compared those data to surveys conducted by other workers between 1981 and 1986. All streams contained newts in the 1980s surveys. The 1994/95 surveys found three streams no longer had newts but did have mosquitofish and/or crayfish. Furthermore, the remaining seven streams that had newts did not have the introduced predators mosquitofish or crayfish. Their subsequent lab studies utilizing small tubs found that mosquitofish would consume larval newts but not the eggs. This correlation study though has a significant limitation. There is no way of really knowing that mosquitofish were responsible for newt disappearance in

the three streams. Many other possible factors, biotic and abiotic could be responsible for newt absence (e.g. human influence on water flows, unknown released contaminants, disease, etc.). Leyse and Lawler (2000, 1998) investigated the relationship between mosquitofish and the California Tiger salamander, *Ambystoma californiense,* in six 3.05 m – by - 6.1 m – by - 0.6 m outdoor experimental ponds. The results of their 1998 experiment showed that mosquitofish presence did not affect either larval growth, weight, size or the number reaching metamorphosis. Their trials with aquaria in the lab indicated young salamander larvae often successfully swam away from mosquitofish when attacked, although a few were consumed. Their second set of pond experiments yielded different results and they reported delayed metamorphosis, tail injuries, decreased weights, and significant reductions in salamander survival. It should be noted that the significant difference between the two experiments was the initial number of fish stocked in the ponds between the two trials. The first trial utilized 12 fish per pond (placed in February) while the second stocked 300 fish per pond. Mosquitofish populations drop to a very low level during the winter months as most adult females and nearly all adult males die during this time period (Swanson et al., 1996). Therefore, when activity begins in the spring there are very few adults remaining and these adults serve as the population that will begin reproduction, which occurs in late spring. Large numbers of fish are typically not observed until well into summer. The higher initial February stocking rate was well beyond what would normally be seen for winter survival and therefore altered the temporal and spatial separation that would otherwise have occurred between salamanders and mosquitofish populations. Segev et al. (2008 **[Ref list has 2009]**) while observing fire salamander (*Salmandra infraimmaculata*) and *Gambusia affinis* populations in three natural pools noted that salamander larvae exhibited damage consistent with mosquitofish biting activity when populations of the mosquitofish were high. They also found the tail:body ratios of the salamander larvae were significantly higher (longest tails) when mosquitofish were absent. When comparing observations for the years 1999 and 2003, which were pre- and post-introduction of mosquitofish for two of the pools, they also found larval salamander densities had significantly decreased. Their mesocosm experiments using 180-liter containers in the lab demonstrated results similar to what they observed in the natural pools, which is *Gambusia* impacted larval salamander survival and size, and fish attacks resulted in damaged appendages.

Invertebrate and planktonic interactions with mosquitofish vary although again it has been suggested from the data and observations that potential impacts may occur. Leyse et al. (2004) tested the effects of mosquitofish on the fairy shrimp, *Linderiella occidentalis* in experimental ponds and found fairy shrimp survival and invertebrate biomass was significantly reduced in ponds with mosquitofish. Their feeding trial studies with lab aquaria also demonstrated that mosquitofish generally preferred fairy shrimp to alternative prey. From their data, they suggested that mosquitofish introductions into naturally fishless wetlands could impact species diversity. Mosquitofish interactions with insects indicate that reductions can occur (Bence, 1982; Farley and Younce, 1977) and may be influenced by the seasonal nature of mosquitofish population density, fish size (which affects prey selection), instar of the insect, and stocking rate (Bence, 1982; Miura et al., 1984; Walton and Mulla, 1991). Planktonic studies have also shown declines in abundance as well as shifts in population structure (Bence, 1988; Bence and Murdoch, 1982; Hurlbert and Mulla, 1981; Margaritoria et al., 2001; Singh, 2013). Of particular interest is the study by Singh (2013) who also found higher pH, dissolved oxygen, and turbidity in ponds following introduction of mosquitofish. Singh concluded that mosquitofish demonstrated a top-down effect on zooplanktonic and phytoplantonic community structure and abundance and therefore could be one of the factors affecting the productivity in Lake Nainital, which had received mosquitofish as part of a mosquito control program in the 1990s.

2.8.2.4 Bats

The concept of bats as effective predators of mosquitoes has been espoused for the better part of 100 years (Campbell, 1925; Felt, 1904: Grinnell, 1918; Howard, 1901; Howard et al., 1912). The biggest surge in this theory came about with the assertions of Dr. Charles Campbell who had been publicly sharing his work with bats and the construction of bat houses near wetlands for many years prior to the release of his 1925 publication titled "Bats, Mosquitoes and Dollars." His work received wide acclaim and

became highly popularized with the general public. Unfortunately, the concerns of scientists with contradictory data from consulted experts, or who were themselves knowledgeable about such matters, went unnoticed (Goldman, 1926; Howard, 1920; Nelson, 1926; Storer, 1926). The link between bats, the construction of bat houses near wetlands, and numbers of mosquitoes affecting people had not been made as there was no definitive data presented from the examination of fecal pellets or gut contents. Ross (1967) provides a summary of the work examining Dr. Campbell's claims.

Fifteen species of insectivorous bats within the families *Molossidae* and *Vespertilionidae* are known to occur within the San Francisco Bay region (see: www.sfbaywildlife.info/species/mammals). The Molossid Bats are: the Brazilian (Mexican) Free-Tailed Bat (*Tadarida brasiliensis*) and the Western Mastiff Bat (*Eumops perotis*). The Vespertilionid Bats are: the Pallid Bat (*Antrozous pallidus*), the Big Brown Bat (*Eptisicus fuscus*), the Silver-Haired Bat (*Lasionycteris noctivagans*), the Western Red Bat (*Lasiurus blossevillii*), the Hoary Bat (*Lasiurus cinereus*), the California Myotis (*Myotis californicus*), the Long-Eared Myotis (*Myotis evotis*), the Little Brown Myotis (*Myotis lucifugus*), the Fringed Myotis (*Myotis thysanodes*), the Long-Eared Myotis (*Myotis volans*), the Yuma Myotis (*Myotis yumanensis*), Townsend's Big-Eared Bat (*Plecotus townsendii*), and the Western Pipistrelle (*Pipistrellus hesperus*). Published research shows that some of these bats do indeed feed on mosquitoes, although the assertion that mosquitoes are a significant or primary part of their diet, which, therefore, makes them effective predators, and by extension good biological control agents of mosquitoes does not always hold true.

Published dietary studies examining gut contents or the guano of bats within San Francisco Bay appears limited. There are a number of observations and studies though from other parts of California and throughout the United States that suggest flies, especially mosquitoes, constitutes a small portion of the diet for most of these bats (Black, 1974; Borell, 1942; Brigham and Saunders, 1990; Buchler, 1976; Easterla and Whitaker, 1972; Feldhamer et al., 2009; Freeman, 1979; Hamilton, 1933; Hatt, 1923; Kunz et al., 1995; Orr, 1954; Perlik et al., 2012; Ross, 1967; Ross, 1961; Whitaker and Barnard, 2005; Whitaker, 1972; Whitaker and Lawhead, 1992; Whitaker et al., 1981a,b; and Whitaker et al., 1996). Midges, belonging to the family Chironomidae have been found in both gut content and fecal pellet analysis to be a significant part of the diet of *Myotis lucifigus* and *Myotis californicus* in western Oregon (Whitaker, 2004; Whitaker et al, 1977). Additional studies by Anthony and Kunz (1977) and Belwood and Fenton (1976) also show aquatic insects, especially midges are important to the diet of *Myotis lucifugus*.

Although gut content and fecal analysis help to confirm and clarify the diets of these bats, care should still be taken when working with and interpreting these data. The different regions where these studies and observations occurred, the insect fauna available as prey items at these locations, and time of year the studies were conducted are but a few of the factors that can account for the variability in diet and behavior of these species of bats. Existing data would indicate that overall, bats may consume some mosquitoes but without further research it is hard to claim bats are an effective biological control agent of mosquitoes. However, the District does make every effort to provide information to interested individuals and organizations about bat conservation.

2.8.2.5 Birds

Insectivorous birds are another of the many potential predators of mosquitoes within bay area wetlands. The San Francisco Bay region supports a number of species of insect eating birds: however, there do not appear to be any that feed exclusively on mosquitoes. Some of these species (e.g. Purple Martins, Swallows) have received considerable promotion as being effective predators of mosquitoes that could, with the erection of nesting boxes and achievement of sufficient population levels, significantly reduce the need for other forms of mosquito control, especially chemical sprays (BirdNote 2014; Blickle 2005 **[Ref list has 2011]**; Make Your Own Bird Food 2014; Rural Survival 2014; Wade, 1966). Unfortunately, feeding observations and gut content analysis studies of these opportunistic insectivores do not support the anecdotal claims for Purple Martins and Swallows being effective biological control agents of

mosquitoes (Beal, 1918; Farley, 1901; Grant, 1945; Jackson and Weber, 1975; Johnston, 1967; Mengelkoch et al., 2004; Orlowski and Karg, 2011; Riggs, 1947; Walsh, 1978).

Kale (1968) reviews Purple Martins and their effectiveness as a biological control agent of mosquitoes. He discusses (as mentioned above) that gut content analysis studies indicated mosquitoes were an insignificant part of their diet. It is further pointed out that these birds typically fly from 100 to 200 feet above the ground, although they can and do fly anywhere from a few inches to an altitude of almost 500 feet. Since mosquitoes tend to remain closer to the ground (below tree canopy) and are usually active during hours that Purple Martins typically are not, this significantly limits mosquitoes as being a viable prey item for these birds. Kale goes on to review literature where attributions and unsubstantiated claims concerning Purple Martins and mosquitoes have been made. Of special interest are the claims made by Wade (1966) wherein Purple Martins could conservatively consume 2,000 mosquitoes per day and when mosquitoes are plentiful up to 10,000-12,000 per day. Kale points out not only is this misleading, it is without any basis in fact. Grossman (1990) reiterates Kale's point and also references another article by Hill (1990 **[Ref list has 1989]**), which discusses a number of Purple Martin myths including their effectiveness as a mosquito predator.

Wiggins (2005) provides a conservation assessment that includes a thorough and detailed review of the exiting literature concerning Purple Martins. The reader is referred to this document for additional information on biology, ecology, information gaps and recommended management practices. Though more specific for the great plains and the rocky mountain region there is still a great deal of useful information on this bird species.

Studies on foraging ecology, and prey size and selection of swallows indicates a preference for smaller prey items, especially small flies (McCarty and Winkler, 1999; McCarty and Winkler 1991; Quinney and Ankney, 1985; Turner, 1982 **[Ref list has 2013]**). This would suggest that mosquitoes, when available, would be opportunistically utilized as a food source. Unfortunately, some species of mosquitoes are active during periods when swallows are inactive. In other instances there are species of mosquitoes whose seasonal abundance does not fully coincide with that of swallows. Lastly, there are some species of mosquitoes that breed within habitats and areas that preclude swallows from being able to readily access and consume them.

The consideration and use of insectivorous birds also has legal constraints. At the federal level there is the protection of migratory game and insectivorous birds under Title 16, Chapter 7. Sections 701 and 702, the Migratory Bird Treaty Act or MBTA, clearly state that it is unlawful to take, possess, import, export, transport, purchase, barter, or offer for purchase, barter or sale, any migratory bird, their eggs, parts, and nests except with a valid permit. There are limited exceptions but local governmental mosquito and vector control agencies are not included. Title 50, Section 10.13 contains the list of migratory birds protected under the MBTA. It should also be noted that some of the species on this list also appear on the list of endangered and threatened species under Title 50, Section 17.11, the Endangered Species Act (ESA). At the State level similar restrictions apply, although permits can be obtained for specific scientific studies and research pursuant to any endangered and threatened species limitations or sensitive habitat concerns. Therefore, if birds were to be an effective biological control agent of mosquitoes, and they were also available and could be utilized, the additional limitations to be addressed include 1) managing the bird population to minimize unintended impacts to other native fauna; 2) making sure there was sufficient habitat and resources for optimal survival of the released birds; 3) making certain the birds are disease free at the time of release and do not unintentionally introduce pathogens into native bird populations; and 4) the release does not significantly increase the potential population of reservoir organisms for vector-borne pathogens.

Kale (1968) points out an additional significant factor concerning the potential of insectivorous birds serving as an effective biological control agent, specifically that even when insects are abundant birds remove a very small proportion. He references the works of Lack (1967) as well as Andrewartha and Birch

(1961 **[missing from ref list]**) noting that the timing of the abundance of insects tends not to coincide with the timing of maximum bird population presence. Therefore, the numbers of birds needed are insufficient to effectively control high pest insect densities. From a historical perspective, the anecdotal accounts of mosquito abundance contained within the diaries of early settlers and explorers (Gray, 1951) would seem to bear this out as the wetlands at the time were pristine and contained abundant populations of birds, bats and mosquitoes.

The potential for the spread of mosquito-borne pathogens, especially West Nile virus, is a concern that needs more research, especially as it relates to birds and mosquito control. Both the Centers for Disease Control (CDC) and the U.S. Geological Survey (USGS) maintain lists of those birds that have tested positive for the presence of West Nile virus. McLean (2006) discusses the impact of West Nile Virus on the North American bird fauna noting that more than 200 different species of birds have tested positive. Although not all birds readily succumb to infection or make for good reservoir hosts there is still much being learned about West Nile virus and its impacts to birds as well as the amplification of this virus in different bird populations. Wheeler et al., (2009) reviews California bird surveillance data from 2004 to 2007 and notes that bird susceptibility varies widely. Oesterle et al. (2009) experimentally infected Cliff Swallows with West Nile virus and suggested that cliff swallows are a competent reservoir host and could therefore play a role in the early season amplification and maintenance of West Nile virus. Since this virus is still relatively new to the North American continent, caution should be exercised, as there is still a lot that is unknown about the relationships of this virus and North American birds.

Therefore, intentionally breeding and mass releasing birds to help manage mosquito populations is not viable at this point in time and could have adverse effects on the ecosystem, including the epidemiology of West Nile virus. The lack of hard data to support the claims of being effective mosquito predators, the potential for mosquito-borne disease issues, and regulatory constraints are but a few of the factors limiting the use of insectivorous birds as a biological control tool. However, the District does make every effort to support and encourage their health and wellbeing of potential mosquito predators. This includes providing information about bird biology, ecology and conservation.

Examples of Tool Use: Examples of mosquito predators include representatives from a wide variety of taxa: coelenterates, *Hydra* spp.; platyhelminths, *Dugesia dorotocephala, Mesostoma lingua, and Planaria* spp.; insects, *Anisoptera, Zygoptera, Belostomidae, Geridae, Notonectidae, Veliidae, Dytiscidae, and Hydrophilidae*; arachnids, *Pardosa* spp.; mosquitofish, *Gambusia affinis*, *Gasterosteus aculeatus*; bats; and birds, *anseriformes, apodiformes, charadriiformes, and passeriformes*.

2.8.3 Applicable to District IVMP

The overall objective of using predators is to reduce the potential need for or frequency of pesticide applications. This minimizes the risk of potential environmental impacts associated with pesticides and minimizes the potential for development of mosquito resistance to pesticides.

Predation on mosquitoes is a natural process that will occur without human intervention. However, the level of mosquito control by natural predators can be increased by the conservation of predators in the environment and by augmentation of the predator population through stocking and habitat enhancement.

References to some of the predators of mosquitoes can be found dating back more than 100 years and help form the basis for much of the research that has occurred since (Beutenmuller 1890; Cattel 1903; Felt 1904; Howard 1901, 1910; Mitchell 1907; Smith 1904; Weeks 1890).

From the review of the above research, it is clear that mosquitofish do have the potential to impact the environments within which they are placed. Yet, it is also important to remember that care should be taken when working with and evaluating the data from the myriad of studies that have been conducted with mosquitofish. While these studies suggest that mosquitofish can reduce populations of amphibians, fish and invertebrates, there are some significant factors to be considered when working with the data. First, the results of many of these studies are laboratory based and utilize artificial environments that are limited in

their ability to emulate natural fully functioning wetland habitats and/or they offer the fish limited prey selection. Second, some studies created outdoor simulated wetland mesocosms; yet even these sites were limited as they did not in many cases have the diversity of microhabitats, vegetation and full range of complex biotic interactions that one might find in well-established natural wetland systems. Third, many studies lacked populations of potential predators of mosquitofish that can be found in natural habitats thus allowing the populations of mosquitofish to exceed levels that would otherwise be found. Fourth, some studies use stocking rates well above those utilized by mosquito control agencies or had stocked ponds with numbers of fish that were much higher than what would occur in the wild for that time of year. Walton (2007) cogently points out that "predation on mosquitofish, environmental complexity and environmental factors may ameliorate the strong effects observed in simple laboratory and mesocosm systems."

Although there is little doubt that mosquitofish are a useful biological control agent of immature mosquitoes, their use and application does have limitations both in terms of effectiveness and in limiting the risk of potential unwanted impacts. The District supports and encourages the presence of the other biological control predators of mosquitoes when practical. Yet, the only readily available biological control agent for use, other than the bacterium *Bacillus sphaericus*, is the mosquitofish. The rearing and stocking of mosquitofish in mosquito breeding habitats is also the most commonly used biological control agent for mosquitoes in the world. Nonetheless, the District's use of mosquitofish is limited and carefully monitored and includes rechecking planted sites to verify presence and abundance. Mosquitofish are typically used as a long-term control measure and therefore are not planted in habitats prone to drying. Fish are placed in closed man-made water features such as ponds, ornamental ponds, water gardens, horse troughs, rain water barrels, and large fountains and care is taken to verify that this biological control agent cannot gain access to unintended habitats, especially creeks and sensitive wetlands. Citizens are also advised of State regulations prohibiting the introduction of nonnative species (e.g. mosquitofish) into waters of the State and the U.S. Operationally, the use of mosquitofish is also limited by factors such as highly polluted water (e.g. dairy lagoons, winery waste ponds, septic ponds), presence or proximity of sensitive species and habitats, and whether or not the mosquito breeding site is a seasonal water source or a permanent impoundment.

Therefore, the District, as mentioned above, limits the use of mosquitofish to those sites with reduced potential for impacts to native species and sensitive habitats to occur. Mosquitofish are stocked only in compliance with federal and state endangered species regulations, so as to avoid the potential to harass and impact threatened and endangered fish, amphibians, insects and other wildlife. District staff is highly-trained, are certified by the California Department of Health Services, and are required to complete frequent continuing education sessions sponsored by the State, the District, or the Mosquito and Vector Control Association of California. Lastly, District staff routinely coordinates and consults with other responsible agencies, including the California Department of Health Services, the California Department of Fish and Wildlife, the U.S. Fish and Wildlife Service, BCDC, the California State Lands Commission, the San Francisco Regional Water Quality Control Board, USACE. to ensure that biological control activities with mosquitofish do not result in significant impacts or substantial adverse effects to biological resources.

2.9 Biological Control Plants

2.9.1 Description

Insectivorous plants have been mentioned as possible biological control agents of mosquitoes for almost 100 years (Howard et al., 1912). One genus of particular interest has been the Bladderworts (*Utricularia* spp.), an aquatic plant which has been studied sporadically for more than 80 years. Other members include, but are not limited to, other species such as Pitcher Plants (*Sarracenia* spp.), the Sundews (*Drosera* spp.) and the Venus Fly Trap (*Dionaea muscipula*). The District is not aware of any native carnivorous plants within the Program area, although there are citizens cultivating carnivorous plants, especially *Sarracenia* spp.

In Matheson's (1930 **[Ref list has 1931]**) review of aquatic plants and mosquito control, he summarizes both previous and current work with *Utricularia* spp. and concludes that these plants deserve further consideration as possible biological control agents of mosquitoes. He also points out that food items were varied, consisting of small crustaceans, protozoa and even some small insects, including immature mosquitoes. Angerilli and Bierne (1974) observed the influence of certain freshwater plants, including *Utricularia minor*, and noted significant but inconsistent levels of mosquito larval predation. Unfortunately, this study had placed these plants in tanks that utilized tap water, which also did not have significant populations of alternative prey items. Baumgartner (1987) studied Bladderworts and their effectiveness as a predator of late fourth instar *Culex pipiens* larvae in the lab and determined that these carnivorous plants do capture mosquito larvae but are inefficient as a biological control agent of mosquitoes. The research of Gordon and Pacheco (2007) examined prey composition of two species of Utricularia in Venezuela and found prey items consisted of rotifers, cladocerans, copepods, rhizopods, annelids, insects and various phytoplankton. It should be noted that algae made up more than 60 percent of prey items while animal forms were the remainder (insects comprising an insignificant amount of the animal taxa consumed). Ogwal-Okeng et al. (2011) worked with *Utricularia reflexa* and another species of carnivorous plant to test their larvicidal activity on Anopheles mosquitoes and concluded that *Utricularia reflexa* significantly reduced mosquito populations and was therefore a potential biological control agent for control of mosquitoes and malaria in Uganda. Again, it should be pointed out that the small tanks used in this study did not accurately reflect natural environmental conditions (e.g. the presence of significant numbers of alternative prey items).

The terrestrial *Sarracenia* spp. seem to be even less effective as predators of mosquitoes. Cresswell (1991) examined the insect prey of 214 pitchers of the Pitcher Plant (*Sarracenia puprurea*) for a period of 55 days. A total of 504 prey items were extracted (503 belonging to 49 families of insects) and only four of these were mosquitoes. Wray and Brimley (1943) collected the prey and inquilines of *Sarracenia flava*, *S, purpurea* and *S. rubra* from five localities in North Carolina, two of the sites being well populated by Pitcher Plants and a quarter acre in size or larger. With the exception of the larval forms of *Wyeomyia smithii*, a species of mosquito whose larvae develop in the water of the Pitcher Plant, four adult mosquitoes were found as prey items. The popular idea that large numbers of pitcher plants prevent human interactions with mosquitoes seems dubious and has yet to be proven beyond what one finds anecdotally.

Drosera spp. also have a wide range of invertebrate prey, although prey composition and capturing efficiency varies depending on the species of *Drosera* involved (Baltensperger 2004; Thum 1986). Other than anecdotal information there appears to be a paucity of scientific research examining the efficiency of Sundew plants as a biological control agent of mosquitoes.

2.9.2 Examples of Tool Use

The District does not employ the use of carnivorous plants.

2.9.3 Applicable to District IVMP

There are vendors of carnivorous plants (nurseries, private dealers, and clubs) where citizens can acquire and also receive information on the cultivation of these plants. The District does not utilize carnivorous plants as a part of its IVMP.

Carnivorous plants, whether terrestrial or aquatic, utilize a wide range of invertebrate prey and are not specific predators of mosquitoes. What little data exists indicates that carnivorous plants, especially terrestrial species, are inefficient for the control of mosquitoes. Therefore, the District does not utilize carnivorous plants as a part of its IVMP.

2.10 Synthetic Insecticides

2.10.1 Description

These manufactured compounds are similar to insecticides derived from plants. In particular, a pyrethroid is an organic compound similar to the natural pyrethrins produced by the flowers of selected chrysanthemums.

2.10.2 Examples of Tool Use

Permethrin, resmethrin, and etofenprox. Etofenprox is applied via ULV equipment to control adult mosquito populations in areas such as oak woodlands and sewage treatment plant facilities.

2.10.3 Applicable to District IVMP

The District currently uses etofenprox and to a limited extent, resmethrin as mosquito adulticides. The method of application is limited to ultra-low volume fogging via truck-mounted, ATV=mounted, or by hand foggers. Deltamethrin as a dust is used to control yellowjackets. Deltamethrin is introduced to ground nesting Yellowjacket nests via hand equipment to eliminate the nests. Wasp-Freeze (d-trans Allethrin and Phenothrin) is used in limited spot applications to control wasps and hornets.

2.11 Botanical Insecticides

2.11.1 Description

Botanical insecticides are derived from natural plants in contrast to the synthetic versions described above. Pyrethrins are botanical insecticides derived from natural plants like chrysanthemum cinerariaelfolium and *C. coccineum*. The essential oils of many plants are used as botanical insecticides.

2.11.1.1 Botanical Insecticides

Botanical insecticides (e.g., pyrethrin) are derived from natural plants in contrast to the synthetic versions described in Section 2.10. Pyrethrin (pyrethrum) is one of the most commonly produced and used natural insecticides and is sometimes used by the District as a part of its IVMP. Pyrethrin is a natural insecticide extracted from certain varieties of the flower *Chrysanthemum cinerariaefolium* and consists of six active ingredients collectively known as pyrethrins (USEPA 2006; Gunasekara 2005; Worthing and Hance 1991). This insecticide provides effective control of adult mosquitoes and other insect pests at very low dosage and has little residual activity (persistence) due to its sensitivity to sunlight. The chrysanthemum flowers used to produce pyrethrins are grown commercially in parts of Africa, Asia, and Australia.

Pyrethrins and pyrethroids exhibit rapid knockdown and kill of adult mosquitoes, characteristics that are considered a major benefit of their use. The mode of action of these compounds relates to their ability to affect sodium channel function in the insects' neural membranes. Their toxicity in insects is markedly increased by the addition of synergists (primarily piperonyl butoxide) which inhibit detoxification of the pyrethrins in insects. No evidence suggests that these synergists increase toxicity in mammals.

Pyrethrins are not cholinesterase inhibitors, are noncorrosive, and will not damage painted surfaces. They are less irritating than other mosquito adulticides and have a less offensive odor. In comparison to other adulticides, pyrethrins may be effectively applied at much lower rates of active ingredient per acre.

The District recognizes that pyrethrins can impact other organisms, especially insects, and therefore takes great care when using this insecticide to minimize effects to nontarget organisms. At mosquito control label application rates, aerial applications with pyrethrins showed no impact on large-bodied arthropods but did have some impact on small-bodied organisms (Boyce et al. 2007). Jensen et al. (1999) found that ULV applications over three seasonal wetlands on Sutter National Wildlife Refuge resulted in no detectable reduction in the abundance or biomass of aquatic macroinvertebrates. However, they did

find a temporary decrease in flying insect abundance in both treated and control wetlands that recovered within 48 hours. Davis et al. (2007) performed an ecological risk assessment of pyrethrins, permethrin, resmethrin, phenothrin, and two organophosphates to warm- and cold-water vertebrates and aquatic invertebrates that may be in a watershed where mosquito spray applications occur, as well as those mammals and birds that would be in the spray zone. They found that the risk quotient for pyrethrin was low, suggesting that the risk to nontarget receptors was most likely small.

The District sometimes uses pyrethrin to manage adult mosquitoes and yellowjackets. The use of pyrethrin is also a least preferred method for controlling mosquitoes, while pyrethrin dust is the primary method for eliminating yellowjacket nests found in the ground. Operationally, the District is very careful when using pyrethrins, as they are not selective for mosquitoes. Therefore, use near beehives is restricted. Additionally, wind restrictions also apply to minimize unwanted drift when making ULV fogging applications.

2.11.2 Examples of Tool Use

Pyrethrins are applied with ULV equipment in areas such as oak woodlands, wetlands, tidal marshes, and around homes.

2.11.3 Applicable to District IVMP

The District currently uses Pyrocide synergized with Piperonyl Butoxide (PBO) as a mosquito adulticide. The method of application is limited to ultra-low volume fogging via a truck-mounted, ATV-mounted, or boat-mounted applicator, or by hand foggers.

2.12 Insect Growth Regulators

2.12.1 Description

Insect Growth Regulators target juvenile harmful insect populations while causing less detrimental effects to beneficial insects. They do not kill adult mosquitoes; and unlike classic insecticides, IGRs do not affect an insect's nervous system. Juvenile hormone must be absent for the mosquito's pupal stage to molt to the adult form, so methoprene treated larvae are unable to successfully become adult insects.

Insect Growth Regulators (IGRs) target immature insect populations, they do not kill adult mosquitoes. IGRs do not affect the insect's nervous system. IGRs can be target specific, depending on the formulation used and the concentration that is applied to the target population of insects being managed. Therefore, adhering to label requirements and when used in the manner for which they are designed, IGRs affect the juvenile stages of the target organisms while causing little or no effects to the nontargets present (e.g., methoprene and mosquitoes). Unlike many traditional insecticides, IGRs do not affect an insect's nervous system, nor do they kill adult mosquitoes. Rather, IGRs prevent the ability of the immature stages to complete their final molt from the pupal stage to adult (prevent adult emergence).

The IGR currently used, and that has been used by the District for more than 2 decades, is s-methoprene. S-Methoprene (known simply as methoprene or as its trade names, Altosid and MetaLarv) is a synthetic analogue (mimic) of a naturally occurring insect hormone called Juvenile Hormone (JH). JH is found during the mosquito's aquatic life stages and in other insects, but is most prevalent during the early instars. As mosquito larvae mature, the level of JH steadily declines until the 4th instar molt, when levels are very low. This period when all the physical features of the adult begin to develop is considered sensitive. Methoprene in the aquatic habitat can be absorbed on contact and the immature mosquito's hormone system then becomes unbalanced. When happening during the sensitive period, the imbalance interferes with 4th instar larval development. One effect is to prevent adults from emerging. Since pupae do not eat, they eventually deplete body stores of essential nutrients and then starve to death. Based on its mode of action, methoprene is considered an IGR. This material has no effect on mosquito pupae and must be contacted by larvae to be effective.

Methoprene is a material with very high specificity in its mode of action. Exhaustive reviews of the published literature on this material demonstrate that methoprene has little or no adverse environmental impact when used at label rates for mosquito control (Anderson et al. 1996; Butler et al. 2010; Glare and O'Callaghan 1999; Hanowski et al. 1997a,b; Henrick 2007; Kenyon and Kennedy 2001; Lawler et al. 2000; Mian and Mulla 1982; Office of the Minnesota Legislative Auditor 1999; Rexrode et al. 2008; Russell et al. 2009; Stark 2005). However, it has been suggested that potential direct and indirect effects may exist for some nontarget organisms subjected to repeated short-term or continuous long-term exposures of methoprene.

Most invertebrate field studies have shown minimal effects to nontarget organisms. Pinkney et al. (2000) investigated the repeated application of Altosid Liquid Larvicide to experimental ponds (rate of 3 ounces per acre or 0.16 ounce AI/acre) and found only isolated instances of reductions of aquatic nontargets. Overall, their analysis of the data indicated no significant differences between the Altosid and control ponds. Invertebrate populations in tidal salt marsh habitats treated with Bti, methoprene, or a combination of Bti and methoprene either were not affected or showed nominal effects with affected nontargets recovering quickly following exposure to methoprene (Lawler et al. 2000, Russell et al. 2009). Hershey et al. (1995) examined the effects of methoprene and Bti on nontarget insects in subdivided temporary woodland ponds and found no evidence of negative effects of larvicide treatments on density or biomass of any invertebrate group or in the richness of benthic fauna. Two studies, however, have suggested that repeated exposure and/or increased duration of exposure may increase the likelihood of nontarget indirect effects (e.g., reduced food resources). Hershey et al. (1998) performed a 3-year study evaluating insect populations in Wright County, Minnesota, wetlands that were treated 6 times from April through July of each year (1991–1993) with Bti and methoprene granules, and had a use pattern of methoprene that subjected wetland organisms to a continuous exposure during each year's test period. Methoprene had minimal effects on nontarget insect groups after the first year of treatment. Reductions in species richness, especially nematocerous flies in the families Tipulidae, Ceratopogonidae, and Chironomidae, were observed during the second and third year. Niemi et al. (1999) completed an integrated 6-year study that assessed the potential ecological impacts of Bti and methoprene use on zooplankton, insects, and breeding birds in Wright County, Minnesota wetlands. Their analysis included the data collected by Hershey et al. (1998), since the same wetlands and Hershey's work was a part of Niemi et al.'s original before and after study design. Changes in insect species richness reported by Niemi et al. was, therefore, simply additional analysis and discussion of the data already reported by Hershey. No negative effects were found to breeding birds or zooplankton as a result of exposure to methoprene, even though reductions in benthic insects were observed. Niemi et al. (1999) also noted that wetlands are ecologically complex and that other factors that may affect species distribution and abundance were not accounted for. Therefore, the lack of close coupling observed among birds, insects, and zooplankton suggests wetlands are highly complex ecological systems requiring additional study to better understand the many abiotic and biotic relationships that make up a wetland system.

Overall, methoprene is an effective tool for the management of immature mosquitoes when taking into account use patterns, material specificity (the large number of organisms that are unaffected at mosquito control rates), application methods, its rapid degradation in the environment, and the volume of published data indicating little or no adverse effects when used at mosquito control label rates. Additional hazard analysis of methoprene is provided in the Ecological & Human Health Assessment Report (see Section 4.3.4) prepared for the PEIR.

2.12.2 Examples of Tool Use

Methoprene liquid, pellets, granules, and briquettes used for control of mosquitoes in freshwater and tidal marshes, seasonal wetlands, ponds, fountains, water gardens, all types of man-made containers, septic tanks, wastewater ponds, winery waste ponds, etc. Methoprene formulations are useful in places that have limited access or where source reduction and routine maintenance are impractical.

2.12.3 Applicable to District IVMP

The District uses S-methoprene products in liquid, pellet, granular, and briquette formulations. Methoprene is a component of the District's IVM program and allows for control of late instar larvae, prevents adult mosquito emergence, provides control for up to several weeks, can be utilized in foul water sources, and can be rotated with the bacterial products.

2.13 Mineral Oils

2.13.1 Description

These products use oil formulations to control mosquito larvae and pupae. Unlike the Bti and Bs bacterial formulations, these oils are effective against pupae and late-stage larvae. The mode of action is via blocking air respiration and altering the surface tension of the water, which also makes them somewhat effective against adult mosquitoes that land on the water to rest or lay eggs. The active ingredient is mineral oil, although CoCoBear Oil, a newer product made by Clarke, is comprised of 10 percent mineral oil, with the remaining oil content being derived from food-grade coconut and vegetable oils.

The District currently uses two surfactants with mineral oil available for mosquito control purposes. BVA-2 and CoCo Bear, are fairly new, function in a similar manner to older products, and contain 97 and 10 percent mineral oil, respectively. Therefore, since an extremely limited body of literature is available concerning BVA-2 or CoCo Bear, literature for Flit MLO and Golden Bear products will be referenced.

Four studies by Tietze et al. (1991, 1992, 1993, 1994) tested three species of fish (inland silversides, mosquitofish, and sheepshead minnows) and a range of microorganisms and concluded that GB-1111 oil was not toxic to the tested organisms at label application rates. Mulla and Darwazeh (1981) experimented with GB-1111 in small experimental ponds and found that benthic invertebrates were unaffected while populations of surface-breathing insects were temporarily reduced following application of this larvicide. Miles et al. (2002) completed a significant independent study of nontarget effects of GB-1111, with US Fish and Wildlife Service's financial assistance, on the tidal marshes of Newark, California, and observed the following effects: (1) surface-breathing insect populations were reduced at the time of treatment; (2) this effect did not persist beyond a few days (= no residual pesticide effects); (3) those potentially affected invertebrates with high mobility left the site, while some of those that could not leave died (especially water boatmen [*Corixidae*]); and (4) overall populations of invertebrate species were not affected, apparently because of recolonization from neighboring untreated sites. They also examined the potential effects on mallard ducklings and noted that the ducklings showed no significant effects of weight loss due to depletion of invertebrate prey. It was observed, however, that some initial oiling and consequent matting of feathers occurred, but that survival, mass and weight gain, and overall condition remained good. Miles et al. (2001) also examined in a lab setting the effects of GB-1111 on hatching success of red-winged blackbird and bobwhite quail eggs and observed reduced hatching success when the eggs were treated with 3 and 10 times the maximum field application (label) rates. It is important to note though that at maximum label rates no significant effects to avian embryos were observed. Subsequent studies by Albers et al. (2003) and Hoffman et al. (2004) yielded similar results when eggs of mallard ducks, red-winged blackbird, and bobwhite quail were exposed to GB-1111 at 3 and 10 times maximum label rates. Both studies also concluded that the potential hazard to embryos was minimal until maximum label rates were exceeded. An earlier study by Albers and Heinz (1983) examined the hatchability of mallard duck eggs and duckling behavior following different levels of exposure to FLIT MLO. At 3 times the maximum label rate, egg hatchability was significantly reduced and changes in behavior, specifically reduced avoidance response, were observed. They concluded that application within label rates did not appear to pose a risk to the embryos of breeding birds.

2.13.2 Examples of Tool Use

BVA 2 Oil, and CoCoBear Oil are used as needed, in aquatic habitats and anthropogenic sources to control mosquitoes and particularly those in the later stages of development including pupae and in foul water habitats.

2.13.3 Applicable To District IVMP

These products are part of the District's existing mosquito control program.

2.14 Mass Trapping

2.14.1 Description

Large numbers of traps, baited with a strong lure (e.g. carbon dioxide, octenol, lactic acid, heat, certain wavelengths of light and sound, and food items such as sugars and proteins) are placed in an effort to catch sufficient target pests to reduce the population to healthful levels. Depending on the species and density of the vector population being managed, traps may be distributed over a large area. Lures for mosquitoes include but are not limited to carbon dioxide, light, heat, and octenol. Yellowjacket traps utilize heptyl butyrate, sugars (e.g. fruits) and/or proteins (meats). An insecticide, rodenticide, food, or a sticky insert may also be used in the trap. Traps utilizing a toxicant or electric grids are covered below in Section 2.15 Attract and Kill.

2.14.1.1 Mass Trapping Mosquitoes

The use of depletion or mass trapping as a possible alternative and/or supplement to the use of pesticides has received considerable attention (Adams, 1996; Consumer Reports, 2003; Day and Sjogren, 1994; Henderson et al., 2006; Hougaard and Dickson, 1999; Kline, 2007, 2006, 2002; Kline and Lemire, 1998; Ogawa, 1988; Quarles, 2003, Smith et al., 2010; Weidhaas and Haile, 1978). This technique utilizes specialized traps, which may also contain attractants to enhance their effectiveness, for collecting large numbers of vector or pest organisms. Recent advances in trap design and advances in understanding the biochemical cues and other factors which attract different vectors to their potential hosts has begun to illustrate the possibilities as well as the limitations of mass trapping as a potential management tool.

For example, Revay et al. (2013) tested the efficiency of seven commercially available mosquito host protection devices including three spatial repellent based products, one type of citronella candle and three traps with CO_2 and/or ultraviolet light attractants. Their data indicated that the ThermaCELL Patio Lantern repelled the most mosquitoes at distances of 10 feet or more from the host when compared to controls. Mosquito traps with attractants on the other hand either increased or had no effect on mosquito biting activity at distances of 10 feet or less from the host when compared with unprotected controls. They also found that the placement of four of any one type of trap, one at each corner of a 4050 and 8192 m^2 area, yielded the best protection with the Blue Rhino Trap being the most efficient, demonstrating a 40.1 percent and 18.1 percent reduction in biting activity respectively.

Henderson (2006) tested the effectiveness of the Mosquito Magnet Pro, which releases a combination of CO_2, heat and moisture, to reduce mosquito abundance in both a rural and urban setting. Although six different species and nearly 2,000,000 mosquitoes were collected over a total of 94 trap nights, it was found that continuous operation of these traps did not significantly reduce mosquito activity for either setting. Hougaard and Dickson (1999) tested both the ABC Pro and the Mosquito Magnet traps for their efficacy in managing adult Western Treehole Mosquito (*Aedes sierrensis*) populations and found the Mosquito Magnet had trapped more treehole mosquitoes while the ABC Pro trap had collected more Little House Mosquitoes (*Culex pipiens*). They concluded from their data that the Mosquito Magnet was an effective tool in "helping control" Western Treehole Mosquitoes in Salt Lake City, Utah. They also pointed out that neither trap eliminated all of the mosquitoes but they did help, especially with the homeowners who felt that some form

of effort was being made to address a challenging mosquito problem where the effectiveness of traditional control methods was limited. Kline (2006) noted the results of two unpublished mass trapping experiments conducted in Florida between 2002 and 2004 using Mosquito Magnet Pro traps. The first was on three small islands associated with the Lower Suwannee Wildlife Refuge where enormous populations of the salt marsh mosquito, *Ochlerotatus taeniorhynchus* would make visitation impossible from May through October. One 23-acre island was selected and a minimum of 21 traps were utilized continuously from June to October of 2003 and 2004. Overall there was a significant reduction in adult biting activity such that no repellent was required while on the island. The second study was a collaborative effort with the United States Department of Agriculture (USDA) and involved a residential area in Gainesville. Two separate neighborhoods were surrounded by twelve Mosquito Magnet Pro traps that also used octenol as an additional attractant. Initial analysis of the data indicated a moderate level of control with a 50 percent reduction in mosquito levels in treated versus untreated residential neighborhoods. Smith et al. (2010) utilized 12 Mosquito Magnet-X traps at a coastal Florida State park and found that the traps did not significantly reduce mosquito numbers compared to the control sites. They further noted that during the latter part of the study mosquito numbers had reached such severe levels that park management requested spraying because of the number of complaints received from users of the park's facilities. They concluded that additional traps, a smaller treatment area, lower mosquito population levels or some combination of all three would be necessary in order to achieve non-pesticide control using mass trapping.

Kline (2007, 2006) also provides an overview of the recent advancements in mass trapping technology and its potential as a mosquito management tool. He notes a number of important concerns significant to the effectiveness of mass trapping as a mosquito management strategy. These are: 1) a thorough understanding of the target mosquitoes' behavior, biology and ecology; 2) which attractants work best since an attractant for one species of mosquito can be ineffective for another; 3) reproductive or biotic capacity; 4) spatial distribution, as this affects placement of the traps; 5) dispersal capacity, as a high dispersal rate, especially with species that travel long distances, poses challenges with managing localized populations and increases the risk of reinvasion from other sites; 6) density of the mosquito population since this can influence the number of traps required; 7) design of the trap and attractant delivery system since no one trap works best for the collection of all species of mosquitoes; and 8) the willingness of the local citizenry to tolerate a lower level of mosquito control in some circumstances and situations. Other factors such as wind, temperature, humidity, density of vegetative cover, species of mosquitoes present, and time of year, also play a part in the effectiveness of these types of traps.

Other potential methods of mass trapping include the use of sound and ovitraps. Walker (1996) and Mankin (2012) both provide a review of the application of sound as a tool for managing insects. Unfortunately, the bulk of the research deals with insects other than mosquitoes. There are however a few studies, most of which seem to be interested in collecting male mosquitoes to learn more about male mosquito ecology and mating competiveness, or to test responses of different species of males to sounds. Ikeshoji et al. (1985) reported that when a black cloth was attached to the base of a tripod and sound traps suspended at different heights above the tripod, that the mean male age and the insemination rate of females resting near the sampling site decreased compared to controls. It was suggested that removal of sound sensitive males by this approach had the potential to be more efficient than other possible male manipulation mosquito control techniques although long term and larger scale trapping experiments were needed. Ogawa (1988) working with *Mansonia* spp. mosquitoes in Malaysia reported that mass trapping of males by an attracting sound was promising. It should be noted though that dry ice and the odor of guinea pigs was also used with the sound traps as this enhanced the attraction of mosquitoes near the traps, most of which were *Mansonia uniformis*. Stone et al. (2013) examined the factors affecting the responsiveness of male *Aedes aegypti* and *Aedes polynesiensis* mosquitoes to sounds and the use of sound traps in the field to better understand male ecology and mating competiveness. It was found that age and mating status influenced the overall responsiveness to sound, while size did not. Traps modified with a device to produce a tone of 465 Hz collected 76.2 percent and 49.7 percent of male *Aedes aegypti* in lab cages and greenhouse enclosures respectively. Traps

modified to emit a tone of 440 Hz collected up to 50.8 percent of male *Aedes polynesiensis* in lab enclosures. In field settings, captures of *Ae. polynesiensis* was higher than *Ae. aegypti*, although the numbers of male *Ae*. *aegypti* captured was low in all field settings. Lastly, when sound emitting traps were placed 16.5 meters from male mating swarms there was no significant difference in the male capture rate between experimental and control traps. Mass trapping of mosquitoes with sound for vector control purposes would at this point in time appear to be ineffective.

Ovitraps help assess egg laying female activity and are widely used as a part of mosquito surveillance and monitoring. These types of traps are specifically designed to attract and sample gravid female mosquitoes, either directly or by means of the eggs that are deposited within the trap. The design varies depending on the species of mosquito being sampled. For example, *Culex* spp. mosquitoes are sampled with larger gravid traps such as the Reiter Gravid Trap. This device has a large dishpan-like plastic tub base, filled with hay infused water or some other water with an attractant, and a small fan with a collection net or chamber placed above to suck in egg laying mosquitoes that are attracted to the water. On the other hand, sampling for certain species of *Aedes* mosquitoes is best accomplished with small dark colored cups or black painted jars containing water and an egg laying surface such as a hardboard paddle or coarse paper strip or paper ring near the water surface. These small style ovitraps are used for sampling *Aedes* spp. eggs and do not collect the egg laying adults. Irrespective of the type of ovitrap used, this tool is not effective at capturing large numbers of mosquitoes and also has other limitations. First, these traps either collect female mosquitoes that have already taken at least one blood meal or the eggs of blood fed mosquitoes. This is counter to a vector control agency's purpose and the public desire of minimizing human vector interactions. Second, the water in the larger traps tends to have a rather strong, unpleasant odor. Having large numbers of these traps about would result in complaints concerning the "unusual" smells in one's yard or neighborhood. Third, these traps tend to be effective at trapping the adults or collecting the eggs of certain species of mosquitoes, especially those that breed in specific types of container water (e.g. Little House, Banded Foul Water, Fish Pond and some species of *Aedes* mosquitoes such as Western Treehole, Asian Tiger and Yellow Fever). Therefore, although useful for assessing female mosquito egg laying activity, these traps do not appear to be a viable means for significantly reducing mosquito populations.

2.14.1.2 Mass Trapping Yellowjackets

Mass trapping of yellowjackets has received considerable attention for almost 50 years (Davis et al., 1973, 1969, 1968, 1967; Ennik, 1973; Landolt et al., 1999; MacDonald et al. 1973; McGovern et al., 1970; Reierson and Wagner, 1978, 1975; Rogers, 1972; Rogers and Lauret, 1968). This technique utilizes small plastic traps that have an attractant, usually heptyl butyrate and/or a protein or sugar food source, to attract and trap foraging yellowjackets. Although useful, the effectiveness of these types of traps varies with the density of the wasp population, location and placement of the traps, timing of use for a given situation, frequency of maintenance, and numbers of traps placed. Braband (2007) performed studies examining the placement of 20 traps, twenty feet apart, around the periphery of an area that measured 100 feet by 100 feet. Near the center they placed three more traps in a triangle, twenty feet apart, to test whether perimeter trapping would reduce yellowjacket numbers in the center of the plot. Although initial results demonstrated little difference in wasps collected between the center and peripheral traps, later work with more plots indicated that peripheral trapping did reduce but not eliminate the presence of yellowjackets in the center area of the test plots. Peripheral trapping of school playgrounds unfortunately was inconclusive and concern was expressed that the risk of being stung at playgrounds may not have been reduced, especially since the traps were designed to attract yellowjackets. MacDonald (1973) evaluated yellowjacket abatement and the merits of toxic baiting, attractant trapping and the potential for biological control. He noted that attractant trapping as an abatement technique was ineffective, especially since the chemical attractants were useful for a limited number of species and only under certain conditions. Although this technology has improved since MacDonald's review, especially with the increased understanding of chemical and food source attractants, and the biology and ecology of the

different species of yellowjackets, it still has limitations. Reierson et al. (2008) reported that the strategic placement of a ring of traps at a picnic food pavilion reduced foraging yellowjacket numbers but that longer term control of one year was achieved only with the use of toxic baits. Cox (2006) reviewed the use of protein and sweet or carbohydrate baits, as well as the timing of the use of these baits, for more effective trapping. She noted the success of a baiting program at Waterfront Park baseball stadium that utilized several hundred traps to reduce yellowjacket numbers to a tolerable level for park attendees. Still attractant trapping as a primary means of managing yellowjackets has issues including timing of trap use, safety and convenience of deployment, consistent routine maintenance, and minimizing contamination.

Effective IPM of yellowjackets involves the interrelated use of a number of techniques including but not limited to, good sanitation, toxic baits, location and destruction of the nests, and attractant trapping. It is the combination of these techniques, especially good sanitation and location and destruction of the nests, that provides the best long-term population management of yellowjackets. Attractant trapping as a primary means of managing yellowjackets has issues including timing of trap use, safety and convenience of deployment, appropriate bait and/or attractant, consistent routine maintenance, and minimizing contamination.

2.14.2 Examples of Tool Use

The District does not employ mass trapping as an abatement measure for the reduction of vector populations.

2.14.3 Applicable to IVMP

There are operational difficulties in placing out and retrieving large numbers of traps for most vectors, the least of which are the volume of traps required, numbers of staff, amount of staff time, access, and travel necessary for this tool to be effective. Mass trapping of mosquitoes has proven to be both costly and in most instances ineffective. Mass trapping of yellowjackets has also has a limited effect on the abatement of yellowjackets, with the traps sometimes becoming an attractive nuisance. When dealing with rodents, the District primarily performs site inspections and provides information on rodent control and exclusion. Therefore, the District does not utilize this methodology as a tool for the abatement of vector populations. Instead, trapping is used to help assess vector and vector-borne pathogen presence and abundance and guide the application of other methodologies such as source reduction, sanitation, biological control, public education, and when necessary the use of pesticides.

2.15 Attract and Kill

2.15.1 Description

The attract and kill tool involves the use of a lure to draw the target vector to a location where the vector organism dies after either feeding on or crawling over the pesticide lure mixture, crawling over or touching an electric grid, or being physically killed by some other mechanical means. There are many different kinds of attract and kill devices such as mechanical snap traps, bug zappers, sticky card traps, and various types of bait stations. Some are specific for the type of vector organism being worked with (e.g. yellowjacket bait stations) while others may be more general in nature (e.g. bug zappers). Their placement and use vary and care must be taken when working with this methodology in order to optimize the intended result.

2.15.1.1 Bug Zapper/Electrocuters

Electric insect management devices or "bug zappers" have a long and varied history with the first publication of an electric fly control device appearing in a 1911 edition of Popular Mechanics Magazine. Later more efficient versions of electric insect control devices to help homeowners and farmers appeared in the same magazine in 1931 and 1934. The first patent was issued in 1934, although it would be a few years before the bug zapper would be readily available on the commercial market.

A bug zapper is a device that attracts and kills flying insects with an electric current. These devices typically consist of a protective cage of plastic or grounded metal bars that contain inside an electrified metal grid with an internal fluorescent light source for emitting violet and ultraviolet light. The protective outer cage prevents people and animals (excluding insects) from touching the high voltage grid. The light attracts insects to the metal grid and when they land on the grid they are electrocuted.

Unfortunately these traps are not effective at killing biting mosquitoes and instead kill large numbers of harmless and beneficial insects (Frick an Tallamy, 1996; Lewis, 1996; Nasci et al., 1983; Science Daily, 1997; Surgeoner and Helson, 1977). Frick and Tallamy (1996) assessed the insects that were killed in electric insect traps from six sites in Newark, Delaware. They noted that of the 13,789 total insects electrocuted, 18 or 0.13 percent were female mosquitoes. Additionally, 1868 (13.5 percent) predatory and parasitic insects, and 6670 (48.4 percent) aquatic insects were killed. Their data suggested, albeit circumstantially, that the bug zapper was not an effective means for significantly reducing mosquitoes in one's yard. Nasci et al. (1983) tested the ability of these types of devices to reduce mosquito biting activity in six adjacent backyards in South Bend, Indiana. They observed that only 3.3 percent of the 3212 insects killed on an average night were female mosquitoes. They also noted that humans were more attractive to mosquitoes than the bug zappers. Surgeoner and Helson (1977) evaluated the effectiveness of electric grid light traps in backyards in southern Ontario and concluded that they did not prove effective in reducing mosquito biting activity. When the release of carbon dioxide was added to the tops of the trap, their effectiveness significantly increased. Still they noted that these traps destroyed large numbers of other types of insects and that mosquitoes constituted a small portion of the total number of insects killed.

Another issue generally overlooked by the general user of these traps is the potential for release of airborne insect particles and microbial contaminants. A number of studies examined the potential for this issue and noted that indeed there was a release of such contaminants when insects, especially certain kinds of flies and moths, were disintegrated in electrocuting insect traps (Ananth et al., 1992; Broce, 1993; Pickens, 1989; Tesch and Goodman, 1995; Urban and Broce, 2000). Pickens (1989) further noted that trap design, placement height of the traps, and potential air movement or wind velocity were important factors in determining the distance of scatter of dismembered parts of electrocuted flies. Under normal circumstances and with proper trap placement, he suggested that a distance of two meters between wall mounted traps and work areas would provide sufficient space to prevent potential contamination. This unfortunately may not be the case for traps used in ones backyard, especially those hanging from porch, patio or deck areas. Again trap design, placement, potential air currents and numbers of insects being zapped at any one time will be the determining factors concerning risks for potential contamination of food and drink items.

2.15.1.2 Attractive Toxic Sugar Baits (Mosquitoes)

Attractive toxic sugar baits (ATSBs) are a technology garnering considerable attention as a potential tool for the management of adult mosquito populations (Beier et al. 2012; Khallaayoune et al. 2013; Muller et al. 2008, 2010a,b,c; Muller and Schlein 2008; Naranjo et al. 2013; Qualls et al. 2014, 2012; Revay et al. 2014; Xue et al. 2006, 2008, 2011). This strategy takes advantage of the fact that adult mosquitoes feed on plant sugars, which are an important source of energy influencing adult mosquito longevity, reproductive capacity, host seeking, and the potential to transmit disease (Andersson 1990; Andersson and Jaenson 1987; Magnarelli 1979, 1983; Nayar and Pierce. 1980; Nayar and Sauerman 1971; 1975; Yuval 1992). Both genders of mosquitoes feed on plant sugars, with some species exhibiting preferences for certain types of nectars or sugars (Grimstad and DeFoliart 1974: Muller et al. 2010a, 2011; Schlein and Muller 2008). Potential sugar sources can include, but are not limited to, flowers, sap, juices of decaying fruits, and honeydew.

ATSBs typically are solutions that consist of a sugar bait base, which contains a toxicant such as boric acid, dinotefuran, Saccharopolyspora spinosa, fipronil, eugenol, garlic oil, or some other microencapsulated insecticide or plant essential oil/extract. Adult mosquitoes are attracted to the ATSB, which may either be

contained within a bait station with an accessible surface allowing mosquitoes to feed on the bait, or is applied as a liquid spray to the foliage of plants and man-made nonporous surfaces (e.g., painted or stained wood, metal, and plastic). Mosquitoes are then killed following ingestion of the ATSB.

Current research results indicate this approach has promise although with some concerns and limitations. First, a limited amount of data exists concerning impacts to nontarget organisms (Khallaayoune et al. 2013; Qualls et al. 2014; Revay et al. 2014). Although the potential impacts to nontarget organisms appear low, more research needs to be done to confirm these results with different formulations, application methods, and in different settings. Second, ATSBs require that a sufficient number of bait stations be placed within the area of mosquito activity (Xue et al. 2008) or that a certain amount of the surface area within a treatment site be covered with the ATSB solution to maximize effectiveness. Sprayed ATSBs must also be applied in a way that uniformly wets, and depending on the formulation, saturates the surfaces of treated foliage and nonporous surfaces. Third, although low, a risk exists that some surfaces may discolor when sprayed with certain liquid ATSB formulations (Universal Pest Solutions Terminix AllClear label 2013). Therefore, care must be taken to minimize potential discoloration of treated surfaces. Fourth, hand watering or automatic irrigation within sites that have been sprayed with an ATSB must be avoided for at least 24 hours, otherwise the material may be washed off and rendered ineffective.

2.15.1.3 Yellowjacket Bait Stations

The toxic baiting of yellowjackets has received considerable attention with a wide variety of potential toxic baits, numbers of bait stations per unit area, bait station designs, bait texture, and wasp foraging habits and behavior having been evaluated (Chang 1988; Ennik, 1973; Grant et al. 1968; Grothaus et al. 1973; Keh et al. 1968; Parrish and Roberts 1983; Reed and MacDonald 1986; Reierson and Wagner 1975; Reierson et al. 2008; Rogers 1972; Ross et al. 1984; Ruddock and Rohe 1968; Spurr 1996, 1995; Wagner and Reierson 1969). Although a useful management strategy, there are potential issues that must be addressed for this tool to be effective. These include but are not limited to: placement of the bait station, type of bait used, texture of the bait used, type of toxicant used, amount of toxicant used, timely bait station maintenance, time of year, and weather conditions.

Many changes have occurred concerning the availability of effective microencapsulated pesticides that can be used in bait stations for the management of yellowjackets. The goal of using toxic baits is to have the foraging yellowjackets take the toxic bait back to the nest where the young and other members of the nest can feed on the bait. As more workers bring back the bait, more members of the nest will die, ultimately resulting in the extermination of the nest. This process can take a few days to two weeks, depending on nest size, weather conditions, and any potential bait shyness issues that might occur. Unfortunately, many of the earlier microencapsulated toxicants (e.g. Knox-Out 2FM and Rabon) are no longer available, with the remaining toxicants being either significantly less effective or having other issues such as repellent properties resulting in bait shyness.

Ultimately, the District has found that the limited availability of effective toxicants for use with baiting has currently made this particular tool of little value as part of its IVMP for yellowjackets. The best strategy for managing yellowjackets involves excellent sanitation practices combined with location and destruction of the nests. Good sanitation practices includes but is not limited to: limiting access to food items by tightly covering waste receptacles; keeping waste receptacles clean; feeding pets indoors or in screened enclosures; not leaving left over pet food in bowls out of doors; properly disposing of containers that contained sweet foods, sweet drinks, and meats; proper disposal of household organic wastes; and minimizing spillage of certain food items such as meats and sugary drinks. When nests are located, contacting the District or a pest control professional is recommended as they have the proper tools and materials to safely and effectively control yellowjacket wasps and, if needed, remove the nest.

2.15.1.4 Rodent Bait Stations and Snap Traps

The effective management of rodent populations, specifically rats and mice, poses many challenges as these organisms are quite adaptable to a wide range of habitats and conditions. Although there are a variety of management strategies, one of the more common techniques is the use of attract and kill technology which employs poison baits or snap traps. This strategy, while useful for helping to manage rodent populations, also has potential issues which can reduce its effectiveness. For baiting these are: bait shyness, resistance, ingestion of sufficient amounts of the toxic bait to be effective, risk of non-target secondary poisoning, location and proper disposal of poisoned rodents, the potential for poisoned rodents to die in wall voids where they are inaccessible resulting in unwanted odors, proper placement of the bait stations, and timely maintenance of bait stations. For snap traps the issues are: proper placement of the traps, use of an effective attractant, adequate number of snap traps, and timely maintenance of traps including removal and disposal of deceased rodents. Since the District utilizes trapping for rodents (e.g. snap traps for rats) on a very limited basis for surveillance only, this form of attract and kill technology will not be discussed any further.

There are a number of different toxic baits that can be utilized for the management of rodent populations. These poisons can be generally grouped as single dose (second generation) or multiple dose (first generation) poisons. Examples of single dose toxicants include: the metal phosphides (e.g. zinc phosphide), the hypercalcemics (calciferol, cholecalciferol and ergocalcifrol), and the anticoagulants (brodifacoum, bromadiolone and difethialone). Examples of multiple dose rodenticides include the anticoagulants chlorophacinone, diphacinone and warfarin.

There are two inherent risks associated with the use of these materials, namely direct access to the poison baits by non-target organisms and indirect exposure via consumption of the poisoned rodent. Direct access is managed by the use of rodent bait stations that are designed to restrict access to the poison baits. These devices are tamperproof and set up to allow mice and rats access to the bait while preventing pets, birds, larger animals, children and unauthorized persons from accessing or being directly exposed to the baits contained within. The second risk, unintended consumption of poisoned rodents or secondary poisoning, requires intensive surveillance for and removal of dead rodents to minimize the risk of indirect exposure of non-target organisms.

The potential for secondary poisoning has received a considerable amount of attention, especially by wildlife managers and organizations that are dealing with unwanted rodent and introduced small mammal populations (Alterio, 2013; Bartos et al., 2012; Eason and Spurr, 2013; Kaukeinen, 1982). Additionally, confirmation of secondary poisoning, especially with anticoagulant rodenticides, has also occurred (Albert et al., 2010; Berny et al., 1997; Berny and Gaillet, 2008; Fournier-Chambrillon et al., 2004; Gillies and Pierce, 1999; Hosea, 2000; Lambert, 2007; Shore et al., 1999; Stone et al., 2003, 1999). The best way to minimize unwanted rats and mice is to remove potential food and water sources, eliminate harborage, and thoroughly seal all points of potential entry. Brown (1969) clearly points out the short term effectiveness poisons have for managing rat populations and the value and long term effects of good sanitation practices. Specifically, a Norway rat population of a city block was subjected to repeated applications of poisons for five years. With each application of toxicants the population markedly declined only to rebound until the next application of poisons. For the next three years only good sanitation practices were employed resulting in population levels that went down and stayed down. Therefore, continual good sanitary practices are an effective means for managing rodent populations in and around businesses and homes.

2.15.2 Examples of Tool Use

At this time there are no effective toxicants for yellowjacket baiting although the District reserves the right to utilize yellowjacket bait stations should an effective and environmentally compatible toxicant become available for use.

2.15.3 Applicable to District IVMP

Due to the limited effectiveness of insect electrocution traps, and their propensity for destroying large numbers of nontarget insects, the District does not use these devices as a part of its IVMP. The District also does not recommend the use of bug zappers to its constituents as a method for dealing with the presence of biting mosquitoes.

ATSBs for the management of adult mosquitoes show promise but are limited in their availability. The District is aware of one commercially available product, Terminix AllClear, which contains an essential oil of garlic. This product is new to the market, registered and released for use in California as of July 2014. The District still needs to operationally test this material, as well as other potential ATSBs, to determine those circumstances where their use may be effective while also having little or no nontarget species impacts. Therefore, although currently not used, the District reserves the right to use ATSBs in the future as a part of its IVMP (which may require additional CEQA analysis). The District has found the limited availability of effective toxicants for use with yellowjacket baiting has currently made the methodology of attract and kill of little value as part of its IVMP. The best strategy for managing yellowjackets involves excellent sanitation practices combined with location and destruction of the nests. Good sanitation practices include, but are not limited to, limiting access to food items by tightly covering waste receptacles; keeping waste receptacles clean; feeding pets indoors or in screened enclosures; not leaving left-over pet food in bowls out of doors; properly disposing of containers that contained sweet foods, sweet drinks, and meats; properly disposing of household organic wastes; and minimizing spillage of certain food items such as meats and sugary drinks. When nests are located, contacting the District or a pest control professional is recommended as they have the proper tools and materials to safely and effectively destroy, and if needed, remove the nest. The use of this strategy for the management of yellowjackets has been inconsistent in its effectiveness, especially with the limited availability of effective bait toxicants. The use of snap traps can help with the management of rodent populations. The District primarily relies on public education and site inspections to help citizens with their rodent issues. Rodent bait stations and rodenticides are currently not employed in the District's IVMP. Limited trapping is done for surveillance rather than rodent control.

2.16 Inundative Releases

Inundative releases are large scale, periodic releases of parasites or predators to quickly control pest populations.

2.16.1 Description

Inundative releases are large-scale, periodic releases of parasites or predators to quickly reduce vector populations. This technique also includes the release of large numbers of genetically modified vectors that have been irradiated, chemosterilized, or have had a gene altered. Inundative releases of predators and parasites can be used in situations where the existing levels of natural enemies are unable to sufficiently reduce vector populations to healthful levels. The use of genetically modified vectors can be for population suppression or to reduce the ability of a vector to harbor and transmit disease. The release of irradiated or chemosterilzed males is similar to the release of predators and parasites in that the goal is vector population reduction. Releases of vector natural enemies or sterile males is not self-sustaining and must be periodically repeated to provide effective long-term control. The use of gene-altered vectors does not have to be regularly repeated as the goal is to introduce a gene into the vector population that is self-sustaining. This introduced gene changes the vector population to a less harmful form and/or reduces or eliminates the vector population entirely. Since potential and known predators and parasites of vectors have been discussed above in Sections 2.5 through 2.9, they will not be addressed further here. Instead, this section will focus on the use of genetically modified vectors. The following discussion is a brief summation of some of the literature concerning genetically modified vectors and their future potential as part of an integrated vector management program:

2.16.2 Examples of Tool Use

2.16.2.1 Genetically Modified Mosquitoes

The use of sterilized or genetically altered mosquitoes for the management of mosquitoes and/or mosquito-borne disease has received and continues to receive considerable attention (Alphey et al. 2002, 2010, 2011; Bellini et al. 2013a,b; Benedict and Robinson 2003; Cha et al. 2006; Corby-Harris et al. 2010; Dame 1985; Dame et al. 1974, 2009; Gould et al. 2006; Harris et al. 2011; Ito et al. 2002; Knols et al. 2007; Laven 1967; Lavery et al. 2008; Lofgren et al. 1974; Lowe et al. 1974 **[missing from ref list]**; Macer 2005**[missing from ref list]**; Morlan et al. 1962; Patterson et al. 1968, 1970, 1975, 1977; Reisen et al. 1982; Scott et al. 2002; Toure et al. 2004; Toure and Knols 2006; Weidhaas 1972; Weidhaas et al. 1962, 1974; Wise de Valdez et al. 2011). This interest has spanned more than 50 years and has intensified with advancements in technology; increased understanding of mosquito population biology, ecology and behavior; pesticide resistance; and malaria drug resistance. Areas of interest include, but are not limited to, male fitness or mating competitiveness, ecology and behavior of genetically modified mosquitoes, field performance, sterilization methods and materials, release methods, site assessment and selection, cultural issues and public concerns, ethical and legal issues concerning the use of genetically modified organisms, biosafety and risk assessment of using them, sustainability of introduced desired traits into a mosquito population, and effectiveness of reducing vector-borne pathogen transmission and occurrence of disease.

Success with the use of this approach has been inconsistent. Benedict and Robinson (2003) summarize the results of sterile and incompatible male releases (also known as sterile insect technique [SIT]) and note that regardless of mosquito species three significant factors have contributed to the observed field failures. The significant factors are production below desired levels, loss of male fitness, and immigration of mosquitoes into the release areas. Mosquito population levels and geographic distribution of the population to be treated may also contribute to the success of sterile male releases for the suppression of mosquito populations. For example, when working with isolated populations (e.g., populations within an isolated geographic area) and moderate population levels, SIT has been effective (Patterson et al. 1970; Weidhaas et al. 1974).

Whether or not SIT can work and be sustainable over a very large geographic area, as well as in circumstances with multiple species of mosquitoes, is not clear at this time. The release of sterile mosquitoes is a complex process involving initial colonization of the relevant species, mass rearing of competitive males for release, packing, transport, and release at the optimum place and time (Dame 1985). Having a good understanding of target population size, which helps determine the release period, number of releases, and ratio of sterile males to indigenous males released, is also important for successful use of this technique. Reduction of male competitiveness by radiation, immigration of fertilized females from outside release zones, and inability of laboratory-bred males to perform in the wild are some of the factors observed to affect SIT efficacy in some field tests (Dame et al. 2009). Even with significant advances in technology and understanding of mosquito population ecology, much is still to be learned about the application and effectiveness of SIT as a potential tool for integrated mosquito management.

Mosquitoes that have had their genetic makeup altered to reduce their ability to harbor and transmit vector-borne diseases such as malaria and dengue have also shown promise. This approach requires the use of a genetically engineered system to give the mosquitoes the desired trait as well as a system, known as "gene drive," to successfully spread the desirable gene into the wild mosquito population. Gene drive is important as it ensures that the desirable gene is passed on to more than half of the mosquito population, continues to spread, and will ultimately replace the undesirable trait (i.e., the ability to harbor and ultimately transmit a pathogen such as malaria). Gene replacement is different from more traditional SIT forms, which are self-limiting and usually emphasize population suppression rather than replacement, the release of large numbers of sterile or incompatible male individuals, and require repeated releases.

One of the more prominent issues associated with genetically modified mosquitoes is public perception. The release of genetically altered organisms into the environment, safety to humans, what they will do, what they may become, potential unforeseen effects, and the actual effectiveness to suppress mosquito populations and/or transmission of mosquito-borne pathogens are all important questions being posed. A number of articles have been published discussing the moral, ethical, social, and legal issues concerning the use of genetically modified organisms for public health purposes (Alphey et al. 2010; Knols et al. 2007; Lavery et al. 2008; Macer 2005, 2007; Ostera and Gosten 2011; Toure and Knols 2006; Toure et al. 2004). Public concern about genetically modified organisms, some of which has been propagated by media sensationalism of "new or mutant organisms," is growing

Ecological and population biology issues create serious challenges to the application of genetically modified mosquitoes for disease control (Scott et al. 2002). Biosafety and concerns involving genetically modified mosquitoes are also significant issues (Ostera and Gosten 2011). Whether a self-limiting (e.g., population suppression or "no bite") or a longer-term self-sustaining approach (e.g., introduction of a desired gene) is used, the success of both bite and no-bite strategies for genetically modified mosquitoes depends on the ability of the altered mosquitoes to spread through the wild population. Although a number of recent developments have occurred, none of the genetically modified mosquito methods has been adequately field-tested and consistently demonstrated as operationally effective. The circumstances by which this technology may be used with local mosquito populations are also unclear and will require significant study to determine if and where this technology can be effectively used. Therefore, the District does not at this time use genetically modified mosquitoes as part of its IVMP.

2.16.2.2 Genetically Modified Yellowjackets

The District is not aware of any research concerning the use of genetically modified yellowjackets for managing population levels. Sterile male technique does not make sense as male yellowjackets do not forage and only leave the nest once to mate with a new queen, which has also recently left the nest. Males die shortly after mating with the new queens, which then overwinter and start new colonies in the spring. Attempting to introduce a gene to suppress yellowjacket population levels also seems unlikely. Therefore, since genetically modified yellowjackets are not available for use, this technique is not a part of the District's IVMP for yellowjackets.

2.16.2.3 Genetically Modified Rodents

A limited body of information is available concerning the use of sterile male rodents for managing rodent populations. Glass (1974) reported on work performed in Oklahoma that found male Norway rats born with an unusual color pattern to be sterile. Observations were initiated to assess the effects of producing and releasing sterile males into a wild population. Although some issues with the experimental design and controls occurred, the data did suggest that within certain situations the eradication of Norway rats may be possible with the use of sterile male rats. Issues such as release rates, feralizing of released males, and monitoring the progress of control were areas in need of additional research. Landreth et al. (1976) studied the influence of sterile males on the reproductive capacity of Norway rats. They observed significant offspring reduction by wild female Norway rats. Outdoor and indoor pen experiments with release ratios of 3:1, 1:1, and 1:3 of sterile males to wild males yielded reductions of 82 and 91, 47 and 66, and 83 and 70 percent, respectively. They concluded that the use of sterile males had potential as a tool for the management of wild rodent populations.

Marsh and Howard (1970, 1973) discuss the prospects of using chemosterilants and genetic control for the management of rodent populations. They note those factors that affect the success of using either of these techniques and suggest that although neither is expected to be a cure-all for rodent problems, both techniques could still be useful. Good chemosterilants possess a degree of specificity, affect both genders (especially the females), produce sterility in a single feeding, and produce permanent sterility. Genetic control, or the selection and enhancement of a desired trait (e.g., a nonlethal gene that results in male sterility) that reduces rodent populations, was less certain. Factors affecting usefulness included

how frequently a selected gene would have to be introduced into a rodent population to overcome dilution, the costs of rearing large numbers of rodents carrying the desired gene for release, and public opinion. Public opinion is very significant, especially if large numbers of genetically modified rodents are needed to bring about a significant decrease in the target population. A "plague" of rodents, even a temporary one, does not sit well with most people, let alone that they are genetically modified and, therefore, might be "super rodents."

Jackson (1972) also discusses the use of chemosterilants as a potential tool for the control of rodents. He notes similar concerns with one exception. He points out that due to the physiology and sexual behavior of domestic rodents, nearly 100 percent of the population would need to be treated to obtain effective control. He also notes the commercial availability of chemosterilants as another limiting factor, which is still an issue today. Therefore, because of the aforementioned issues, limited research data on use and effectiveness, and lack of commercially available genetically modified rodents, this technique is not a part of the District's IVMP.

2.16.2.4 Genetically Modified Ticks

Limited research has been done concerning the genetic modification of ticks as a means of managing tick populations and the transmission of tick-borne diseases. A single experiment is known and was performed by Galun et al. in Israel in 1967 **[missing from ref list]**. In this study, they successfully mass reared and irradiated ticks and noted that irradiated males exhibited some reduction, though nominal, of mating competitiveness with normal males. They also determined the optimum effective dose for sterilization and suggested that under certain, restricted circumstances, with more research, this technique had the potential to be a useful management tool.

The idea of using genetically modified ticks as part of an integrated vector management program sounds intriguing. However, potential issues exist. Fully understanding the behavior, biology, and ecology of the various tick species; dependence on hosts for dispersal; the ability to mass rear various tick species; determining what level of radiation or chemosterilization will effectively sterilize but not reduce male mating competiveness; and potential public concern over the possibility of being exposed to large numbers of released biting ticks are but a few of the many unknowns. The likelihood that genetically modified ticks could be a useful tool seems unlikely and, therefore, this strategy is not a part of the District's IVMP for ticks.

2.16.3 Applicable to District IVMP

Inundative releases of genetically modified mosquitoes is still experimental. Genetically modified rodents and ticks have received very little attention from researchers. The District is unaware of any examples of work with genetically modified yellowjackets at this time.

Genetically modified vectors are not commercially available and, therefore, are not used by the District at this time.

2.17 Regulatory Control

2.17.1 Description

Governments use regulatory control measures such as quarantines and hold notices to prevent the human-aided movement of pests and/or items likely to harbor the pest into their jurisdiction or the movement of pests from infested areas into uninfested areas within their jurisdiction.

2.17.2 Examples of Tool Use

This control method is not used in the District’s program.

2.17.3 Applicable to District IVMP

Regulatory actions only prevent the human-aided movement of unwanted pests. They do not reduce pest numbers or the ability of the pest to spread on its own.

2.18 Repellents

2.18.1 Description

There are materials that can be applied to humans and animals that will repel pest insects from landing on them and then laying eggs or feeding. Repellents are used to protect individuals from being bitten. They do not kill the pest, nor do they reduce pest numbers. They force the pests into adjacent areas away from the treated areas or individuals.

2.18.2 Examples of Tool Use

As an educational tool, the District makes different types of repellent wipes available at its booth at public events such as fairs, festivals and the District Open House day. District staff use repellent materials and wear repellent-treated clothing as a safety measure during field work.

2.18.3 Applicable to District IVMP

Repellents are not used as a widespread control measure as they will not reduce large numbers of problem insects or mammals and may even enlarge the infested area by driving the pest away from treated sites.

2.19 Other Chemical Control

In addition to the pesticides described previously in Sections 2.6, 2.10, 2.11, 2.12, and 2.13, this section covers the surfactant Agnique MMF.

2.19.1 Description

Various methods using chemicals for mosquito control are commercially available, but the only such tool currently considered by the District is the biodegradable, alcohol ethoxylated (AE) surfactant compounds such as Agnique MMF. AE's are readily biodegradable under aerobic and anaerobic conditions) and are made from renewable plant oils. Agnique MMF can be applied to any mosquito habitat with standing water. Using conventional application methods, an invisible monomolecular film rapidly spreads over the surface of standing water habitats. This film interrupts the critical air/water interface in the mosquito’s larval and pupal development cycle causing them to drown.

2.19.2 Examples of Tool Use

Agnique MMF is applied to standing water in an neglected swimming pool to control mosquito populations.

2.19.3 Applicable to District IVMP

The sole tool in this class of surfactants currently in use by the District is the type of product exemplified by Agnique MMF.

3 Screening of Tools

Reasonable alternatives are developed through a review of the feasibility of all identified potential tools. To be feasible, the alternative should be capable of accomplishing project purposes in a successful manner in California within a reasonable period of time. This section explains the process for determining the components of the 2014 Program.

3.1 Program Objectives

The District undertakes mosquito and vector control activities through its Program to control the following vectors of pathogens and/or injury and discomfort in the Program Area: mosquitoes, rats, mice, yellowjackets, ticks, or other stinging/biting insects. Surveillance and testing, but no control, is provided for tick vector species.

The Proposed Program's specific objectives are as follows:

> Reduce the potential for human and animal disease caused by vectors

> Reduce the potential for human and animal discomfort or injury from vectors

> Accomplish effective and environmentally sound vector management by means of:

- Surveying for vector abundance/human contact
- Establishing treatment guidelines
- Appropriately selecting from a wide range of Program tools or components

Most of the relevant vectors are quite mobile and cause the greatest hazard or discomfort at a distance from where they breed. Each potential vector has a unique life cycle, and most of them occupy several types of habitats. To effectively control them, an integrated vector management program (IVMP) must be employed. District policy is to identify those species that are currently vectors, to recommend techniques for their prevention and control, and to anticipate and minimize any new interactions between vectors and humans. Furthermore, the District is committed to using the least environmentally disruptive tools in its IVMP.

3.2 Criteria

The District has a well-defined process for selecting tools to be used in mosquito and/or vector control. The criteria used for determining the viability and ranking of reasonable tools are listed below:

> **Criterion 1.** The District uses tools known to be effective to manage vector species on a widespread level that have developed breeding populations in the State.

> **Criterion 2.** The District does not use experimental or hypothetically effective tools on a broad scale (but does engage in trial applications with newly developed/released products).

> **Criterion 3.** Given equal efficacy and operational constraints, the District will use the least environmentally disruptive tool in its control Program.

3.3 Tool Selection Guidelines

The following guidelines (i.e., additional considerations) are used when applying criteria above to the potential mosquito and/or vector management tools:

> Are there effective control measures for the target pest or closely related species?

> Are these tools available for use in California?

> Are these tools likely to be effective if used in the District's Service Area?

> Are there environmental circumstances that will likely limit the effectiveness or operational aspects of the tools in natural, rural, or urban settings?

> Are there operational constraints that will limit the effectiveness of the tools?

3.4 Evaluation Results

Table 3-1, Screening with Criteria, shows the results of the scoring for each of the 21 tools described in Section 2 for the key criteria. Table 3-2, applies the tool selection guidelines to those tools meeting program criteria. Some alternatives were eliminated from the analysis because they were infeasible or did not meet the overall objectives of the Program, or would not meet the criteria and guidelines for selection. This section concludes with a discussion of how tools remaining (following screening with the criteria and the guidelines) were refined further.

Table 3-1 Screening with Criteria

Alternative Tools	Criteria		
	1 **Method Known to be Effective?**	**2** **Not Experimental or Hypothetical?**	**3** **Least Environmentally Disruptive?**
1. Integrated Pest Management	Y	Y	Y
2. Vector Surveillance	Y	Y	Y
3. Physical Control	Y	Y	Y
4. Vegetation Management	Y	Y	Y
5. Biological Control Pathogens (Viruses)	N	N	N/A
6. Biological Control Pathogens (Bacteria)	Y	Y	Y
7. Biological Control Parasites	N	N	N/A
8. Biological Control Predators	Y	Y	Y
9. Biological Control Plants	N	N	Y
10. Synthetic Insecticides	Y	Y	N
11. Botanical Insecticides	Y	Y	N
12. Insect Growth Regulators	Y	Y	Y
13. Mineral Oils	Y	Y	N
14. Mass Trapping	N	N	N/A
15. Attract and Kill	N	N	N
16. Inundative Releases (Parasites)	N	N	N/A
17. Inundative Releases (Other)	N	N	N/A
18. Regulatory Control	Y and N	Y	Y
19. Repellents	Y and N	Y	Y
20. Other Chemical Control (plant oil surfactant)	Y	Y	Y

Y = Yes
N = No
N/A = Not Applicable

ATSBs for the management of adult mosquitoes show promise but are limited in their availability. The district is aware of one new commercially available product, Terminix® AllClear, which contains an essential oil of garlic. The District still needs to operationally test this material, as well as other potential ATSBs, to determine those circumstances where their use may be effective while also having little or no nontarget species impacts.

The District evaluated vector control methods by screening the methods listed in Table 3-1 against the three criteria contained in Section 3.2 above. Tools not passing this screening were eliminated from further analysis, while those passing are further analyzed against the guidelines listed in Section 3.3 and shown in Table 3-2 below.

Table 3-2 Tool Selection and Application Guidelines

Alternative Tools	Guidelines				
	Effective Control Measures?	**Tools Available in California?**	**Tools Effective in District Service Area?**	**Environmental Circumstances Limiting Effectiveness or Operational Aspects of Tools?**	**Operational Constraints Limiting Effectiveness of Tools?**
1. Integrated Pest Management	Y	Y	Y	N	N
2. Vector Surveillance	Y	Y	Y	N	N
3. Physical Control	Y	Y	Y	Y	Y
4. Vegetation Management	Y	Y	Y	Y	Y
5. Biological Control Pathogens (Bacteria)	Y	Y	Y	Y	Y
6. Biological Control (Other)	Y	Y	Y	Y	N
7. Synthetic Insecticides	Y	Y	Y	N	Y
8. Botanical Insecticides	Y	Y	Y	N	Y
9. Insect Growth Regulators	Y	Y	Y	N	Y
10. Mineral Oils	Y	Y	Y	Y	Y
11. Chemical Control (plant oil surfactant)	Y	Y	Y	Y	Y

Y = Yes
N = No
N/A = Not Applicable

3.4.1 Alternatives Considered and Withdrawn from Evaluation

The District determined that of the 20 potential tools from Table 3-1, the following eight methods were not immediately available for use in its IVMP: biological control pathogens (viruses), biological control (parasites), mass trapping, attract and kill, inundative releases (both parasites and other), regulatory control, and repellents.

> *Biological Control pathogens (viruses)* is deemed infeasible as this method is not commercially available in California and there are currently many efficacy related issues.

> *Biological Control (parasites)* is deemed infeasible as this method is not commercially available in California. Research on the use of parasites for mosquito control has also shown several limitations related to efficacy.

> *Mass Trapping* is not considered by the District to be a practical, effective, reliable method of controlling vector populations. Can be very expensive and time consuming (i.e., labor intensive).

> *Attract and Kill* is not considered by the District to be a practical, effective, reliable, method of controlling vector populations. The technology for both mosquitoes and yellowjackets is limited, and effectiveness is either not obtained or is inconsistent. Nontarget insects can be impacted. The District is aware of one commercially available ATSB product, Terminix® AllClear. The District still needs to operationally test this material, as well as other potential ATSBs, to determine those circumstances where their use may be effective while also having little or no nontarget species impacts.

> *Inundative Releases of parasites* is not considered by the District to be a practical or currently feasible method of controlling vector populations. They are not commercially available and remain experimental at this time.

> *Inundative Releases of predators* either sterilized or genetically altered organisms, is not considered by the District to be a practical or a currently feasible method of controlling vector populations. Genetically modified vectors are still experimental. They are also not commercially available at this time.

> *Regulatory Control* is not considered feasible because adoption of regulations is lengthy, time intensive, expensive and uncertain as to the regulatory outcome. This approach is not focused sufficiently on control of existing populations. Moreover, regulatory controls are dependent upon state and federal agencies to initiate and implement, and thus this approach cannot assure that any project objectives would be achieved.

> *Repellants*, although effective for small-scale use by humans and animals, are not part of the overall Program control strategy because they merely displace the problem and do not reduce the mosquito population in an area.

3.4.2 Refinement of Selected Tools

Of the remaining potential tools, the following were determined to be effective for mosquito and/or vector control activity: surveillance, physical control, vegetation management-physical, vegetation management-herbicides, biological control pathogens (bacteria), biological control predators, botanical and synthetic insecticides, insect growth regulators, and mineral oils. Of these tools, further evaluation of the options under each of these methods, including how to deliver the material, was conducted.

3.4.2.1 Vector Surveillance

This tool was found to be an essential component of the District's IVMP.

3.4.2.2 Physical Control

This tool was found to be an essential component of the District's IVMP.

3.4.2.3 Vegetation Management

This tool was found to be an essential component of the District's IVMP.

Physical Controls

These methods of source control include, but are not limited to, vegetation and water management and maintenance activities to reduce habitat values. See Section 3.5.3.1 herein.

Herbicides

This class of products is not generally used by the District .However, in the course of source reduction activities, cooperating public agencies sometimes request that the District assist them by applying herbicides under their permits. Since District staff may apply herbicides under these circumstances, this tool was incorporated into the environmental analysis.

3.4.2.4 Biological Control Pathogens (Bacteria)

> Bacillus thuringiensis israelensis (Bti) This tool is used by the District.

> Bacillus sphaericus (Bs) This tool is used by the District.

> Saccharopolyspora spinosa (Spinosad) This tool is not currently used by the District but is being studied and considered.

3.4.2.5 Synthetic Insecticides

All of the following potential synthetic insecticides were evaluated.

> Permethrin

> Zenivex E20 (Etofenprox)

> Pyrocide (Pyrethrin)

> Deltamethrin

> Resmethrin

3.4.2.6 Natural Insecticides

> Pyrethrin

3.4.2.7 Insect Growth Regulators

> Methoprene in various formulations: liquid, pellets, briquets.

3.4.2.8 Mineral Oils

> BVA 2 Oil

> CoCoBear Oil

3.5 Selected Program Alternatives

The District has selected a systems approach over several years using multiple tools and depending upon conditions at specific locations. The District utilizes an overall IPM approach in order to use procedures that will minimize potential environmental impacts. The District's Program employs IPM/IVM principles by first determining the species, distribution and abundance of mosquitoes/vectors through evaluation of public service requests and field surveys of immature and adult mosquito/vector populations and, then, if the populations exceed predetermined guidelines, using the most efficient, effective, and environmentally sensitive means of control. For all mosquito species, public education is an important control strategy. In some situations, water management or other physical control activities can be instituted to reduce mosquito-breeding sites. The District also uses biological control such as the planting of mosquitofish in some settings: ornamental fish ponds, ponds, water troughs, water gardens, fountains, and neglected swimming pools. When these approaches are not effective, or are otherwise deemed inappropriate, then pesticides are used to treat specific vector-producing or vector-harboring areas.

Three core tenets are essential to the success of a sound IVM program:

> First, a proactive approach is necessary to minimize impacts and maximize successful vector management. Elements such as thorough surveillance and a strong public education program make a major difference in reducing potential human vector interactions.

> Second, long-term environmentally based solutions (e.g., water management, reduction of harborage and food resources, exclusion, and enhancement of predators and parasites) are optimal as they reduce the potential pesticide load in the environment as well as other potential long- and short-term impacts.

> Lastly, utilizing the full array of options and tools (public education, surveillance, physical control, biological control, and when necessary chemical control) in an informed and coordinated approach supports the overall goal of an environmentally sensitive vector management program.

The District's Program consists of the following alternatives, which are general types of coordinated and component activities, as described below. The Proposed Program is a combination of these alternatives with the potential for all of these alternatives to be used in their entirety along with public education as described below.

3.5.1 Surveillance

Vector surveillance, which is an integral part of the District's responsibility to protect public health and welfare, involves monitoring vector populations and habitat, their disease pathogens, and human/vector interactions. Vector surveillance provides the District with valuable information on what vector species are present or likely to occur, when they occur, where they occur, their abundance, and if they are carrying a pathogen(s) or otherwise affecting humans. Vector surveillance is critical to an IVM program because the information it provides is evaluated against treatment guidelines to decide when and where to institute vector control measures. Information gained is used to help form action plans that can also assist in reducing the risk of disease transmission. Equally important is the use of vector surveillance in evaluating the efficacy, cost effectiveness, and environmental impacts of specific vector control actions.

3.5.1.1 Mosquito Surveillance

Mosquitoes in nature are distributed within their environment in a pattern that maximizes their survival to guarantee reproductive success. Immature stages develop in water and later mature to a winged adult that is capable of both long- and short-range dispersal. This duality of their life history presents vector control agencies with unique circumstances that require separate surveillance strategies for the aquatic versus terrestrial life stages.

Surveillance involves monitoring the abundance of mosquito populations, their habitat, mosquito-borne disease pathogens, and the interactions between mosquitoes and people over time and space. The District routinely uses a variety of traps for surveillance of adult mosquitoes, regular field investigation of known mosquito sources for direct sampling for immature stages, public service requests for adult mosquitoes, and low ground pressure all-terrain vehicles (ATVs) to access these sites. The District conducts surveillance by way of a variety of activities that include:

> **Field counting/sampling and use of trapping**, along with the laboratory analysis of mosquitoes, and pathogens to evaluate population densities and potential disease threats such as WNv, WEE, and SLE. Sampling of presence and abundance of mosquito populations tends to occur in areas where the citizenry would have a likelihood of exposure to them or in habitat occurring within the mosquito species flight range to populated areas. Field counts take place both at immature and adult stages of mosquito development or life cycle. Three kinds of traps, host-seeking traps, light traps, and gravid/oviposition traps, are used as described below:

- Host-seeking traps use dry ice (carbon dioxide) and/or a synthetic lure (e.g. Octenol) to attract female mosquitoes behaviorally cued to seek a host to blood feed. The trap's components include

a container/reservoir for attractant (e.g. dry ice), a battery power source, a low ampere motor/fan combination, and a collection bag for holding captured adults. These types of traps may also include a small light source (e.g. lamp) as an additional attractant for mosquitoes.

- Light traps (commonly called New Jersey Light traps) use a source of photo-attraction such as an incandescent lamp (25-watt) or fluorescent lamp (7-watt) where they are pulled in by the suction provided by an electric (110 v AC) appliance motor/fan combination. Mosquitoes picked up by the suction are directed downward (via screened cone) inside the trap body to a glass or plastic collection jar containing a 1-inch strip of Vapona, Hot Shot®, or No-Pest® strip (Dichlorvos). The collection jar is enclosed within an expanded metal cage with a hinged trap door that is padlocked.
- Oviposition traps are used to collect gravid *Culex* spp. mosquitoes and/or to measure their egg-laying activity. This trap uses an infusion, such as 5-day-old hay-infused water contained in a small plastic dish pan that has a 6-volt battery-operated fan directly above to draw the gravid female mosquitoes into the small collection net.

Mosquito immatures include eggs, four larval stages, and a transitional pupal stage. Mosquito control agencies routinely target the larval and pupal stages to preclude an emergence of adults. Operational evaluation of the presence and abundance of immature mosquitoes is limited to the larval and pupal stages, although the District may sample eggs for research reasons. Sampling and collection of the immature stages (egg, four larval stages, and a transitional pupal stage) involves the use of a 1-pint dipper (a standardized small plastic pot or cup-like container on the end of a wood or metal handle), which scoops up a small amount of water from the mosquito-breeding site. Operationally, the abundance of the immatures in any identifiable "breeding" source is measured through direct sampling, which provides relative local abundance as the number of immatures per sample and/or area of the source. This method requires access by field personnel to within about 3 feet of larval sites at least every 2 weeks in warm weather. The spatial patchiness of larvae requires access to multiple locations within each source, rather than to single "bell-weather" stations.

> "Arbovirus"[1] surveillance to determine the likelihood and occurrence of mosquito-borne illness is accomplished by two methods commonly used in California: (1) capturing and testing female vector mosquitoes for the presence of mosquito-borne encephalitis viruses as explained above and (2) periodic testing for the presence of encephalitis virus-specific antibodies in the blood serum of either sentinel chickens, domestic or wild birds. The first method involves the use of host-seeking traps to capture female vector mosquitoes. Captured females are sorted into groups of up to 50 (called pools) and tested via one of two methods. Testing may be carried out in the District's laboratory using a method such as real-time polymerase chain reaction or submitted to UC Davis to test for the presence of mosquito-borne viruses. The District uses method (2) above through the placement of caged chickens as "sentinel birds." Since the viruses of major concern (WNV, WEE, and SLE) are diseases actively transmitted by mosquitoes to both birds and to humans through bites, caged chickens' routine blood samples will reveal whether one or more of the virus-specific antibodies are present. The chickens are placed generally 6 to a caged area (at least 6 by 12 feet or larger), are humanely treated, and are provided ample shelter with nest boxes, water, and feed. Chickens are used as the early detection system for virus transmission, as they are unaffected by the presence of these viruses in their systems. At the end of the mosquito season, the chickens are adopted out. In addition, the District participates in the State's dead bird pickup program as part of its West Nile virus surveillance program. Dead birds are assessed for condition and if they are suitable, collected by the District, and then sent for West Nile virus testing at a State laboratory.

[1] Arthropod-borne viruses. The primary reservoir for the pathogens that cause these diseases is wild birds, and humans only become exposed as a consequence of an accidental exposure to the bite of infective mosquito vectors.

> Field inspection of known or suspected habitats where mosquitoes live and breed. Sites where water can collect, be stored, or remain standing for more than approximately 96 hours are potential habitats for mosquito breeding that require continuous inspection and surveillance. Water runoff into catch basins and stormwater detention systems from land uses including, but not limited to, residential communities, parks and recreation areas, and industrial sites, as well as ornamental ponds, neglected swimming pools, seeps/seepages, seasonal wetlands, tidal and diked marshes, freshwater marshes, wastewater ponds, sewer plants, winery waste/agricultural ponds, managed waterfowl ponds, canals, creeks, streams, tree holes, tires, man-made containers, flooded basements/crawl spaces, and other standing waters are likely sources.

> Maintenance of paths and clearings to facilitate sampling and to provide access to vector habitat. It is District policy that staff use preexisting roads, trails, walkways, and open areas to conduct routine and essential surveillance activities if possible and to minimize impact on the environment. Surveillance is conducted on foot or by using ATVs, low-pressure ground vehicles and boats, but off-road access is minimized and used only when necessary.

> Analysis of public service requests and surveys and other methods of data collection.

The District's mosquito surveillance activities are conducted in compliance with accepted federal and state guidelines, in particular the *California Mosquito-borne Virus Surveillance and Response Plan* (CDPH et al. 2013) and *Best Management Practices for Mosquito Control in California* (CDPH and MVCAC 2012).These guidelines recognize that local conditions will necessarily vary and, thus, call for flexibility in selection and specific application of control methods.

3.5.1.2 Tick Surveillance

The District performs surveillance of ticks (e.g. *Ixodes pacificus*) to survey the incidence tick-borne diseases such as, Lyme disease (*Borrelia burgdorferi*), ehrlichia, anaplasma, and rickettsia species by way of the following practices:

> *Collection* of ticks in public contact areas to (a) determine the location of ticks infected with tick-borne diseases such as, *Borrelia burgdorferi* and (b) to determine the seasonal and geographical distribution of the ticks according to species. Ticks are typically collected by "flagging" vegetation along trails. Stiff fabric is dragged for specified distances along the trails to stimulate ticks to attach to the material. Then they are manually removed and placed in vials for transport back to the laboratory for testing.

> *Identification* of ticks brought in by the public, which are usually found biting persons or their domestic animals.

> *Submission* of tick-borne disease test results to the appropriate Public Health Agency (e.g., CDPH). The District also provides tick-borne disease test results and tick abundance data to government agencies and the public. The District on occasion submits tick samples to CDPH for testing.

> *Dissemination* of educational information to the public concerning ticks, Lyme disease, and other tick-borne diseases.

3.5.1.3 Rodent Surveillance

The District responds to public and agency service requests regarding rats and rat populations. The monitoring and control work focuses on domestic rats including Norway rats (*Rattus norvegicus*), roof rats (*Rattus rattus*) and on house mice. Norway rats are known to invade homes and businesses from sources such as sanitary sewers. Property inspections in response to public service requests involve looking for entry ways, rodent burrows, and signs of rodent infestation.

Testing for the presence of hantavirus pulmonary syndrome may be conducted by collecting wild rodents. For hantavirus surveillance, small traps are placed in suspect areas including peridomestic habitats along

the urban fringe or rural areas. The traps are checked the following day to remove any rodents for sampling. Blood samples are submitted for testing.

3.5.1.4 Yellowjacket and Other Wasps

Venomous biting and stinging insect encounters often require the response of District staff. It is important to educate the residents that while these insect bites and stings may potentially induce life-threatening allergic reactions and pain, overall, these insects serve beneficial roles as pollinators and biological control agents.

The District responds to public service requests and provides recommendations and control measures for nonstructural pest populations of yellowjackets. Problems involving bee swarms are referred to the local beekeepers association and/or the County Agricultural Department.

Other Vector Surveillance

Ground squirrels (*Spermophilus beecheyi*) and other sylvatic rodent surveillance for the plague consists of sampling by trapping with blood samples sent to the California Department of Public Health (formerly Health Services) (CDPH), Vector-Borne Disease Section for testing. These animals may also be tested for tularemia. Testing for the presence of plague and murine typhus might be conducted by collecting ground squirrels, opossums, and fleas in addition to wild rodents described in Section 2.3.1.3 above. Small animals will be trapped using live traps baited with food. The traps will be set in late afternoon and will be collected within 24 hours. The animals will be anesthetized and blood, tissue, and flea samples will be obtained. Threatened and endangered species and other legally protected animals that may become trapped will be released immediately and will not be used in these tests.

The two primary reservoir vectors of rabies in California are bats and skunks. Both live in close proximity to humans and their pets because of their ability to adapt to the urban/suburban environment. Residential landscapes provide them with an abundance of food and shelter options that have increased their numbers and the potential for direct contact with the human population. This is true for all wildlife and therefore a potential rabies health threat exists. The District works with home and property owners to discourage wildlife (primarily by providing referrals and information) such as skunks and bats from taking up residence in areas frequented by humans, pets, and livestock on their property. Upon a service request, personnel from the District will survey the property and provide guidance and recommendations on exclusion methods to minimize vector impact on the property.

The District responds to requests from the public to provide information about bed bugs. The Centers for Disease Control and Prevention (CDC) and the United States Environmental Protection Agency (USEPA) have jointly said that bed bugs are a public health nuisance pest. Their biting can cause welts (however, not everyone will react to bed bug bites). Under heavy infestations, asthma or allergy can be problematic for children and senior citizens. The District's bed bug protocol includes the following educational activities:

> Positively identify a specimen brought to the District to confirm that it is a bed bug.

> Educate members of the public on likely bed bug infestation signs (e.g., skin cast, blood stains).

> Provide information on ways to reduce clutter, improve sanitation, make repairs, and use pillow and mattress encasements.

> Advise using passive monitoring devices (e.g., Climb Up or Night Watch bed bug detection devices).

> Advise on hiring a reputable and experienced pest control operator to control the bed bugs.

> Remain neutral on landlord/tenant bed bug disputes.

3.5.2 Physical Control

Managing vector habitat to reduce vector production or migration, either directly or through public education is often the most cost-effective and environmentally benign element of an IVM program. This approach to the control of vectors and other pests is often called "physical control" to distinguish it from those vector management activities that directly rely on application of chemical pesticides (chemical control) or the introduction or relocation of living agents (biological control). Other terms that have been used for vector habitat management include "source reduction," which emphasizes the significance of reducing the habitat value of an area for vectors, or "permanent control," to contrast with the temporary effectiveness of pesticide applications.[2] Vector habitat management is important because its use can reduce or virtually eliminate the need for pesticide use in and adjacent to the affected habitat and, in some situations, can virtually eliminate vector production from specific areas for long periods of time, reducing the potential disturbances associated with frequent biological or chemical control activities. The intent is to reduce the abundance of vectors produced or sheltered by an area while protecting or enhancing the habitat values of the area for desirable species. In many cases, physical control activities involve restoration and enhancement of natural ecological functioning, including production and dispersal of special-status species and/or predators of vectors.

3.5.2.1 Mosquitoes

Physical control for mosquitoes consists of the management of mosquito-producing habitat (including freshwater and tidal marshes and lakes, saltwater marshes, temporary standing water for approximately 96 hours or more, and wastewater treatment facilities) especially through water control and maintenance or improvement of channels, tide gates, levees, and other water control facilities. Physical control is usually the most effective mosquito control technique because it provides a long-term solution by reducing or eliminating mosquito developmental sites and ultimately reduces or eliminates the need for chemical applications. The physical control practices may be categorized into three groups: maintenance, new construction, and cultural practices.

Maintenance activities are conducted within tidal, managed tidal, and nontidal marshes, seasonal wetlands, diked, historic bay lands, and in some creeks adjacent to these wetlands. The following activities are classified as maintenance:

1. Removal of sediments from existing water circulation ditches
2. Repair of existing water control structures
3. Removal of debris, weeds, and emergent vegetation in natural channels
4. Clearance or trimming of brush for access to streams or wetland areas
5. Filling of existing, nonfunctional water circulation ditches to achieve required water circulation dynamics and restore ditched wetlands

New construction typically involves the creation of new ditches to enhance tidal flow preventing stagnant water.

Cultural practices include vegetation and water management, placing culverts, bridges or other engineering works, and making other physical changes to the land. These practices reduce mosquito production directly by improving water circulation and indirectly by improving habitat values for predators of larval mosquitoes (fish and invertebrates), or by otherwise reducing a site's habitat value to mosquito larvae.

[2] This terminology can be misleading if periodic maintenance is needed for physical control devices or structure.

The District performs these physical control activities in accordance with all appropriate environmental regulations (e.g., wetland fill and dredge permits, endangered species review, water quality review, streambed alteration permits, see Section 2.7), and in a manner that generally maintains or improves habitat values for desirable species. Major physical control activities or projects (beyond the scope of the District's 5-year regional wetlands permits with the United States Army Corps of Engineers (USACE), San Francisco Bay Conservation and Development Commission, and Regional Water Quality Control Board) are addressed under this PEIR where known and identified. Minor physical control activities (covered by the regional wetlands permits) are also addressed in this PEIR. They vary substantially from year to year, but typically consist of up to 10,000 linear feet of ditch maintenance. Under the regional permits, the District's work plans are reviewed annually by trustee and other responsible agencies prior to initiation of the planned work. Completed work is inspected by USACE, United States Fish and Wildlife Service (USFWS), California Department of Fish and Wildlife (CDFW, formerly Fish and Game), and other responsible agencies.

The District may request/require landowners and stewards to manage and maintain their properties to minimize the potential for vector production and vector-borne disease or to abate existing production. Maintenance can include: clear debris from drainage channels and waterways; excavate built-up spoil material; remove water from tires and other urban containers; cut, trim, mow, and harvest aquatic and riparian plants (but not including any mature trees, threatened or endangered plant species, or sensitive habitat areas); and install minor trenching and ditching. The District advises landowners and stewards to consult with regulatory agencies regarding the need for agency review and permitting if it appears that natural habitat and nontarget species could be affected.

3.5.2.2 *Other Vectors*

Physical control for other vectors such as rats, mice, raccoons, skunks, and opossums is based on site inspections by the District to determine conditions promoting harborage and signs of infestation. Property owners are provided educational materials on control measures that include removal of food sources (such as pet food, bird/squirrel feeders, and fruit from trees) and blockage of access points into the structure. If the vector is posing a health or safety risk, then removal by trapping is employed by means of referral to a licensed private pest control operator.

Three elements are necessary for a successful rodent management program: sanitation, exclusion, and rodent proofing.

> *Sanitation:* Correcting sanitation deficiencies is basic in rodent control. Eliminating food sources through good sanitation practices will prevent an increase in their populations. Sanitation involves good housekeeping, including proper storage and handling of food materials and pet food. For example, store pet food in metal, rodent-proof containers. For roof rats, thinning dense vegetation will make the habitat less desirable. Algerian or English ivy, star jasmine, and honeysuckle on fences or buildings are very conducive to roof rat infestations and should be thinned or removed if possible.

> *Exclusion:* Sealing cracks and openings in building foundations, and any openings for water pipes, electric wires, sewer pipes, drain spouts, and vents is recommended. No hole larger than 0.25 inch should be left unsealed to exclude both rats and house mice. Doors, windows, and screens should fit tightly. Their edges can be covered with sheet metal if gnawing is a problem. Coarse steel wool, wire screen, and lightweight sheet metal are excellent materials for plugging gaps and holes.

> *Rodent proofing* against roof rats requires more time to find entry points than for Norway rats because of their greater climbing ability. Roof rats often enter buildings at the roofline area so be sure that all access points in the roof are sealed. If roof rats are traveling on overhead utility wires, the District recommends/encourages the property owner to contact a pest control professional or the utility company for information and assistance with measures that can be taken to prevent this access.

While activities designed to reduce vector populations through changes in the physical environment are considered Physical Control, they must be distinguished from activities related to rearing or relocating predators of vectors, which are discussed below as "Biological Control," as well as those tools that impact vector habitat through manipulation of vegetation, which are described below as "Vegetation Management" practices.

3.5.3 Vegetation Management

3.5.3.1 Physical Control

The species composition and density of vegetation are basic elements of the habitat value of any area for mosquitoes and other vectors, for predators of these vectors, and for protected flora and fauna. District staff periodically undertake vegetation management activities, or encourage and provide suggestions to others on how to do so on their property, as a tool to reduce the habitat value of sites for mosquitoes and other vectors or to aid production or dispersal of vector predators, as well as to allow access by District staff to vector habitat for surveillance and other control activities. The District encourages property owners to consult with regulatory agencies and to inquire regarding the need for an agency consult or permit. Direct vegetation management by District staff generally consists of activities to reduce the mosquito habitat value of sites by improving water circulation or access by fish and other predators, or to allow access by District staff to standing water and/or known sources of mosquito production for inspections and treatment if necessary.

For vegetation management, the District uses hand tools or other mechanical means (i.e., heavy equipment) for vegetation removal or thinning and sometimes applies herbicides if requested and provided by other agencies (chemical pesticides with specific toxicity to plants) to improve surveillance or reduce vector habitats. Vegetation removal or thinning primarily occurs in aquatic habitats to assist with the control of mosquitoes and in terrestrial habitats to help with the control of other vectors. To reduce the potential for mosquito breeding associated with water retention and infiltration structures, District staff may systematically clear weeds and other obstructing vegetation in wetlands and retention basins (or request the structures' owners to perform this task). In particular, thinning and removal of cattail overgrowth would be done to provide a maximum surface coverage of 30 percent or less. In some sensitive habitats and/or where sensitive species concerns exist, vegetation removal and maintenance actions would be restricted to those months or times of the year that minimize disturbance/impacts. Vegetation management is also performed to assist other agencies and landowners with the management of invasive/nonnative weeds as it pertains to mosquito source reduction or access to sources of mosquito production (e.g., *Spartina*, *Pepperweed*, *Arundo*, *Tamarix*, and *Ailanthus*). These actions are typically performed under the direction of the concerned agency, which also maintains any required permits.

Tools ranging from shovels and pruners to chain saws and "weed-whackers" up to heavy equipment can all be used at times to clear or trim plant matter that either prevent access to mosquito breeding sites or that prevent good water management practices that would minimize mosquito populations. Generally, however, District "brushing" activities involve the use of hand tools. Trimmed vegetation is either removed and disposed of properly from the site or placed and/or broadcast in such a way as to minimize visual degradation or impacts to the habitat. Trimming is also kept to a minimum to reduce the possibility of the invasion of exotic species of plants and animals. Regulatory agency consultation, coordination with the landowner, and acquisition of necessary permits are completed before any work is undertaken. Follow-up inspections are also conducted to verify that the work undertaken was effective and that the physical manipulation of the vegetation did not result in any unintended overall habitat degradation.

In addition, the use of water management to control vegetation is in some ways an extension of physical control, in that water control structures created as part of a physical control project may be used to directly manipulate hydroperiod (flood frequency, duration, and depth) as a tool for vegetation management. Where potential evapotranspiration rates are high, water management can also become a mechanism for salinity management and, indirectly, vegetation management through another path.

3.5.3.2 Herbicides

Herbicides the District may apply in coordination and collaboration with other agencies as a source reduction measure and to achieve habitat enhancement or restoration are listed in Table 2-1 in the PEIR. All herbicides are applied in strict conformance with label requirements.

3.5.4 Biological Control

Biological control of mosquitoes and other vectors involves the intentional use of vector pathogens (diseases), parasites, and/or predators to reduce the population size of target vectors. It is one of the principal components of a rational and integrated vector control management program. Biological control is used as a method of protecting the public from mosquitoes and the diseases they transmit without the use of pesticides and potential problem of pesticide resistance; however, the use of pathogens involves chemical treatment with USEPA-registered materials. The different types of biological controls are described in the following paragraphs.

3.5.4.1 Mosquito Pathogens (Viruses and Bacteria)

Mosquito pathogens include an assortment of viruses and bacteria. Pathogens are highly host-specific and usually infect mosquito larvae when they are ingested. Upon entering the host, these pathogens multiply rapidly, destroying internal organs and consuming nutrients. The pathogen can be spread to other mosquito larvae in some cases when larval tissue disintegrates and the pathogens are released into the water to be ingested by uninfected larvae. Examples of viruses that can infect mosquitoes are mosquito iridoviruses, densonucleosis viruses, nuclear polyhedrosis viruses, cytoplasmic polyhedrosis viruses, and entomopoxviruses. Examples of bacteria pathogenic to mosquitoes are *Bacillus sphaericus* (Bs), the several strains of *Bacillus thuringiensis israelensis* (Bti), and *Saacharopolyspora spinosa*. Two bacteria, Bs and Bti, produce proteins that are toxic to most mosquito larvae, while *Saacharopolyspora spinosa* produces compounds known as spinosysns, which effectively control all larval mosquitoes. Bs can reproduce in natural settings for some time following release. Bti materials applied by the District do not contain live organisms, but only spores made up of specific protein molecules. All three bacteria are naturally occurring soil organisms that are commercially produced as mosquito larvicides.

3.5.4.2 Mosquito Predators

Mosquito predators are represented by highly complex organisms, such as insects, fish, birds, and bats that consume larval or adult mosquitoes as prey. Predators are opportunistic in their feeding habits and typically forage on a variety of prey types, which allows them to build and maintain populations at levels sufficient to provide some level of mosquito control (i.e. depending on predator species), even when mosquitoes are scarce. Examples of mosquito predators include representatives from a wide variety of taxa: coelenterates, *Hydra* spp.; platyhelminths, *Dugesia dorotocephala, Mesostoma lingua, and Planaria* spp.; insects, *Anisoptera, Zygoptera, Belostomidae, Geridae, Notonectidae, Veliidae, Dytiscidae, and Hydrophilidae*; arachnids, *Pardosa* spp.; mosquitofish, *Gambusia affinis*, *Gasterosteus aculeatus*; bats; and birds, *anseriformes, apodiformes, charadriiformes, and passeriformes*. Only mosquitofish are commercially available to use at present, while the District supports the presence of the other species as practical.

The District's rearing and stocking of mosquitofish in mosquito habitat is the most commonly used biological control agent for mosquitoes in the world. These fish are ideal control agents for several reasons. They feed primarily at the water's surface, where larvae can be found. They can tolerate a significant range in water temperature and water quality. They are also easy to handle, transport, stock, and monitor. Correct use of this fish can provide safe, effective, and persistent suppression of a variety of mosquito species in many types of mosquito sources. As with all safe and effective control agents, the use of mosquitofish requires a good knowledge of operational techniques and ecological implications, careful evaluation of stocking sites, use of appropriate stocking methods, and regular monitoring of stocked fish. Mosquitofish reproduce in natural settings, for at least some time after release. District policy

is to limit the use of mosquitofish to contained sources such as, ornamental fish ponds, water troughs, water gardens, fountains, waste ponds, and neglected swimming pools. Limiting the introduction of the mosquitofish to these sources should prevent their migration into habitats used by threatened, endangered, or rare species. On average, the District releases about 30 pounds of mosquitofish annually.

3.5.5 Chemical Control

Chemical control is a Program tool that consists of the application of nonpersistent insecticides (and herbicides noted in Section 2.3.3 above) to directly reduce populations of larval or adult mosquitoes and other invertebrate threats to public health. If and when inspections reveal that mosquitoes or other vector populations are present at levels that trigger the District's guidelines for chemical control – based on the vector's abundance, density, species composition, proximity to human settlements, water temperature, presence of predators and other factors – District staff will apply pesticides to the site in strict accordance with the pesticide label instructions.

3.5.5.1 Synthetic Insecticides

Synthetic insecticides are pest management products produced in a laboratory and in some cases may also be a synthetic version of naturally occurring pesticides (e.g., pyrethroids that are a synthetic version of naturally occurring pyrethrin). The District currently uses the product Zenivex (Etofenprox when it is necessary to treat for adult mosquitoes. A diluent, such as BVA 13, may be used to increase the application volume.

The District currently has a relatively small amount of the product Scourge (Resmethrin) to apply when necessary for adult mosquito control.

The District may also consider the use of additional synthetic adulticides if necessary (e.g. if adulticide resistance issues arise). Adulticides the District may consider are listed in Table 2-3 in the PEIR.

3.5.5.2 Natural Insecticides

Natural insecticides are those materials made directly from plants or other organisms such as bacteria. Some of these materials, such as Bti, are highly host specific, while others such as pyrethrin are not.

Botanical insecticides are derived from plants (e.g., pyrethrins from chrysanthemum flowers). The District uses pyrethrin to manage adult mosquitoes and yellowjackets. The District currently uses Pyrocide (i.e. MGK 7067) when it is necessary to treat for adult mosquitoes. The active ingredient (pyrethrin) is derived from natural sources.

Pyrethrins break down rapidly (usually within hours) when exposed to sunlight. The District recognizes that pyrethrins are not selective for mosquitoes. Therefore, use near beehives is restricted. Additionally, wind restrictions also apply to minimize unwanted drift when making ULV fogging applications. Pyrethrin for adult mosquito control is applied at a rate of less than 1.0 ounce per acre using a ULV fogging machine. Pyrethrin dust for the treatment of yellowjacket nests is applied at a maximum rate of 2 ounces per nest and is performed with a handheld bulb duster that blows the pyrethrin directly into the nest.

Insecticides derived from bacteria (e.g., Bti) typically consist of a chemical by-product and/or protein spore produced directly from the organism. The bacterium Bti produces spores containing protein molecules or crystals that are toxic to most immature mosquitoes. The various formulations of Bti used by the District contain no live bacteria but only the spores with protein molecules. Bti efficacy is reduced in highly organic or polluted waters, low temperatures, areas with high larval densities or when dense vegetative cover interferes with application at the mosquito-breeding site. Additionally, timing of the application is critical to maximize effectiveness as the adult, pupal, and late 4th instar larval stages of mosquitoes are not susceptible to Bti. Even with the above limitations, Bti is highly effective and, therefore, a preferred method for the management of mosquito populations when predators, biological control, and habitat manipulation strategies are ineffective. This material comes in liquid, granular, water

dispersed granule, and water-soluble packet formulations. The liquid formulations of this insecticide are applied using hand, truck, boat, or ATV-mounted application equipment, or by fixed wing or rotary winged aircraft. Historically, powdered formulations were mixed with sand and a small amount of mineral oil to act as a binding agent, and then the mix was applied with a handheld granular spreader. The District may in the future use powdered Bti, if and when it becomes available again, and,- therefore,- makes mention of it here to keep it as an available option for larval mosquito control. Water soluble packets are used to help control larval mosquitoes that are present in small containers, ornamental water gardens, stormwater detention systems- and storm drains. Water-soluble packets are only applied by hand.

Another bacterium, *Saccharopolyspora spinosa*, produces compounds known as spinosyns, which are toxic to immature mosquitoes. Like Bti some physical and environmental conditions can limit the effectiveness and use of this material. Unlike Bti, rates near maximum label rates have been shown to affect a few species of nontarget organisms, while lower rates appear to be more specific to immature mosquitoes. Research has demonstrated that mosquito larvae are highly sensitive to spinosyns, although additional research is needed to confirm minimum effective field rates for mosquito control purposes. Although relatively new as a mosquito control product and not currently used, the District reserves the right to include and use this material as a part of its IVMP.

3.5.5.3 Insect Growth Regulators

IGRs target immature insect populations. IGRs can be target specific, depending on the formulation used and the concentration that is applied to the target population of insects being managed. Therefore, adhering to label requirements and used in the manner for which they are designed, IGRs affect the juvenile stages of the target organisms while causing little or no effects to the nontargets present (e.g., methoprene and mosquitoes). Unlike many traditional insecticides, IGRs do not affect an insect's nervous system, nor do they kill adult mosquitoes. Rather, IGRs prevent the ability of the immature stages to complete their final molt from the pupal stage to adult (prevent adult emergence).

Methoprene is a synthetic juvenile hormone that is used by the District to manage mosquito populations. This insecticide is most effective on the late instar larval stages. It is absorbed on contact and causes an imbalance in the hormone system of the mosquito resulting in its inability to complete metamorphosis to the adult stage. The maximum label rate for application of this insecticide for mosquito control is many magnitudes below the levels that could impact other nontarget organisms, specifically invertebrates, amphibians, and fish, making it a good tool for use in the District's IVMP. Persistence and bioaccumulation in the environment are also insignificant as methoprene readily biodegrades in the presence of ultraviolet light and is also readily metabolized; hence, the timing of applications for this material are essential for optimal effectiveness. The half-life of methoprene is about 2 days in water, 2 days in plants, and 10 days in soil. Formulations used by the District are liquid, granules, and briquets. Both the granules and briquets are slow release formulations that allow for concentrations just sufficient to prevent adult emergence of mosquitoes to occur for up to 150 days. Methoprene formulations are applied using hand, boat, truck-or ATV-mounted application equipment, or by fixed wing or rotary winged aircraft. Briquette formulations are applied by hand to mosquito sources such as, small man-made containers, water gardens, fountains, abandoned swimming pools, stormwater detention systems, and storm drains.

3.5.5.4 Mineral Oils/Surfactants

Mineral oil and ethoxylated alcohol formulations (also known as surfactants) are used to control immature stages of mosquitoes (larvae and pupae). This control is accomplished by changing the surface tension of the water resulting in suffocation. These materials can also affect any adult mosquito that tries to land on the water to rest or lay eggs. The current surfactants the District currently utilizes are BVA-2 Oil and Coco Bear Oil. Agnique MMF is currently not being manufactured, although it is possible that it or a like material may become available in the future and it is, therefore, included as a part of the District's IVMP. The active ingredient in BVA-2 is mineral oil. Coco Bear Oil is comprised of 10 percent mineral oil with the remaining oil content consisting of food grade coconut and vegetable oils. Agnique MMF is 100 percent

ethoxylated alcohol. All of these materials can be applied using hand, truck , boat or ATV-mounted application equipment.

3.6 Future Tools under Development and Stud

Saccharopolyspora spinosa (i.e. Spinosad) is currently under study and consideration for potential future use. Additional insecticides may also be studied and implemented into the IVM program as necessary (e.g., see Tables 2-1, 2-2, and 2-3 in the PEIR). ATSBs are also under evaluation.

4 No Project Alternative

No Project is defined as what would reasonably be expected to occur in the foreseeable future, based on current plans and consistent with available infrastructure and community services, if the project was not approved and implemented. For the District, the Proposed Program is to continue current activities and introduce similar pesticides to those currently in use if needed. The No Project/No Program condition assumes that the current activities would cease and result in a "do-nothing" alternative. It must be evaluated in comparison to the existing condition for California Environmental Quality Act compliance.

Key assumptions for the No Project alternative are:

> Current regulatory controls would continue and expand as needed; however, the District would not engage in implementing any of these regulations concerning public health and management of vectors carrying potential pathogens. For all practical purposes, the District's office would close and public education and other outreach activities would cease along with the control activities.

> Private landowners would manage mosquito and/or vector problems on private land without any state or federal oversight with pesticides approved for use.

> Private landowners would also manage vector habitats (clearing, brushing, and draining) with potentially little or no oversight.

4.1 Implications of No Project Alternative

"Doing nothing" as the No Project Alternative has potentially serious implications for public health, economic, and environmental conditions in the District's Program Area.

4.1.1 Public Health

A wide range of public health issues would occur with the No Project Alternative, First, risk of human cases of vector-borne disease and vector interaction issues for humans, pets and wildlife would increase. The San Francisco Bay Area has a well-documented history concerning human-vector interaction, especially with mosquitoes. The earliest written record dates back to the 1772 diaries of Father Juan Crespi who described the "swarms of mosquitoes" in the Warm Springs Area of the City of Fremont and below the hills of Berkeley (Bolton 1927; Gray 1951). Additional records include the 1810 journal entry of mosquitoes attacking a detachment of soldiers near the Albany Hills as well as references indicating that the indigenous peoples of the Bay Area would take action to avoid the large numbers of mosquitoes present during certain times of the year. Note that these interactions took place at a time when the Bay's wetlands and sensitive habitats were essentially pristine, having limited human habitation and little or no draining, filling or modification, or loss of wildlife including predators of mosquitoes.

Second, the lack of any form of coordinated surveillance reduces the ability of any agency to perform disease risk assessments and, therefore, predict potential outbreaks. Although vector-borne disease is not as prevalent as in other areas of the world, vector-borne pathogens are still present. The city of San Francisco has had a history of plague (Anderson 1978; Link 1955; Stimson 1939), and the plague organism is still present in the San Bruno Hills (CDPH 2004, 2002, 2001; Kartman 1964; Kartman et al. 1958; Murray 1964; Quan et al. 1960). Other rodent-borne pathogens such as Hantavirus have also been detected in mouse populations in Alameda, Contra Costa, Marin, Napa, and San Mateo counties (CDPH 2007, 2006, 2005, 2001). Tick-borne pathogens for diseases such as lyme borreliosis, tularemia, ehrlichiosis, and rocky mountain spotted fever have also been found in tick populations throughout the Bay Area, with human cases also reported. West Nile virus, although introduced in 2005, is present throughout the Bay Area, with positive birds, human cases, and some infected horses still detected and reported every year. Malaria continues to be a concern as introduced cases are detected in travelers

returning from malaria-infected regions and some recent immigrants every year. The vector for this pathogen can be found in many areas of the San Francisco Bay region, and reintroduction of the malaria organism into local mosquito populations is monitored closely. The last known endemic transmission of malaria occurred in the Putah Creek area of Napa and Solano counties in 1939.

Third, lack of coordinated surveillance increases the risk of emerging infectious diseases or vectors going undetected until they have become established. The appearance of West Nile virus in New York City in 1999 is an excellent example. For budgetary and other reasons, New York had significantly reduced their vector surveillance and management program many years prior to 1999. By the time the virus had been identified, a number of human cases had already occurred and the virus had become well established. Now the virus is endemic throughout the US and results in numerous cases nationwide. Similarly, the reintroduction of vector-borne diseases such as malaria and dengue that had not been present for many years or even decades could also go undetected until their reestablishment or an outbreak of human cases (Brunetti et al. 1954; Gubler and Clark 1995; Maldanado et al. 1990; Radke et al. 2012; Singal et al. 1977).

Fourth, lack of public outreach results in less current information being available about vectors and vector-borne disease risk reduction. This lack can lead to increased production of vectors on private property as well as increased cases of vector-borne disease in humans, their pets, and livestock. Additionally, the increase in vector-human interactions would result in an increased risk of severe reactions to the bites and stings of vector organisms (e.g., mosquitoes, ticks, and wasps) in sensitive and immunocompromised individuals. Research over the last 75 years has documented cases of hypersensitivity and/or severe reactions to mosquito bites in children, immunocompromised individuals, and persons infected with the Epstein-Barr virus or being treated with zidovudine for the AIDS virus. (Brown et al. 1938; Diven et al. 1988; Galindo et al. 1998; McCormack et al. 1995; Peng et al. 2004; Seon et al. 2013; Simmons and Peng 1999; Smith et al. 1993; Weed 1965). Crisp and Johnson (2013) provide a review of mosquito allergy including immunology, diagnosis, and treatment and conclude (1) treatment should focus on avoidance including limiting breeding sites for mosquitoes as well as the use of repellents and protective clothing, (2) local immediate reactions can be managed with the use of prophylactic antihistamines, (3) individuals with severe or anaphylactic reactions to mosquito bites should carry with them Epi-Pens (autoinjectable epinephrine), and (4) more research is needed in a number of areas concerning management and treatment of patients with hypersensitivity to mosquito bites.

The reaction of persons to vector stings and bites, especially mosquito bites, clearly brings into question the use of the terms "nuisance" and "pest" that have commonly been used in the past to define the difference between those vector organisms that transmit vector-borne diseases (i.e., malaria, West Nile virus, Tularemia, Lyme Disease, Plague) and those that do not. The use of these terms is a misnomer and should not be used to characterize the importance of one vector over another. Human-vector interactions result in a wide range of mental, emotional, and physical responses, all of which have health implications even in the absence of pathogenic organisms. California Health and Safety Code, Division 104, Part 11, Chapter 1, Section 116108 defines a vector as "any animal capable of transmitting the causative agent of human disease or capable of producing human discomfort or injury including, but not limited to, mosquitoes, flies, other insects, ticks, mites, and rats." This definition inherently recognizes that human discomfort and injury as a result of human-vector interactions, is by its own nature, an issue of health just as important as any vector-borne agent of human disease.

4.1.2 Economic Conditions

A number of economic issues are associated with the No Project Alternative. First, with increased human-vector interactions comes an increase in the number of cases of vector-borne disease. The short-term medical and lost workplace, school, and home time associated with illness can cost governments, businesses, families, and individuals upwards of many thousands of dollars (Armien et al. 2008; Barber et al. 2010; Clark et al. 2005; Gubler 2002; Halasa et al. 2012; Meyers 1922; Shepard et al. 2011; Suaya et al. 2009; Tam et al. 2012; Torres 1997; Von Allmen et al. 1979; Vora et al. 2014; Wettstein et al. 2012).

For long-term severe cases that result in paralysis, persistent fatigue, muscle weakness, and/or decreases or loss of cognitive function, this cost can mean millions of dollars to families and federal and state governments (Staples et al. 2014; Utz et al. 2003; Villari et al. 1995). Although not as common, no monetary value can be adequately calculated for the loss of life due to vector-borne disease. Additionally, the loss of valuable livestock (e.g., horses) and decreased farm productivity can also be significant (Abbitt and Abbitt 1981; ASTHO no date; Byford et al. 1992; Cattell 1916; Gadsen Times 1980; Geiser et al. 2003; Herrick 1903; Hoffman and McDuffie 1963; Howard 1909; Mongoh et al. 2008; Steelman et al. 1973, 1972; Williams et al. 1985).

Second, increased vector populations can lead to reduced outdoor recreation activities by the public (Halasa et al. 2014), resulting in increased usage of electricity for air conditioning and indoor entertainment such as television, video games, computers, lighting, etc. These increases could also lead to a reduction in revenues for recreational areas such as parks, campgrounds, marinas, and other areas that depend on usage fees to help with their maintenance and staffing. Outdoor activities are also significant to tourism, which for many areas is an important part of their economy. Large vector populations and/or reported cases of vector-borne disease can impact tourism and potential revenues (Gaiser 1980; Kirka 1989; Merco Press 2008; The Hindu 2007; Wagner and Magee 1977; Williams 1986).

Third, increased vector populations not only lead to increased levels of vector-borne disease but can also result in decreased property values (Herms and Gray 1944; Howard 1909). Within San Francisco Bay, historical mosquito populations were at times so severe as to impact real estate sales (Gray 1951). The impact of mosquito control work on property values is also illustrated by Headlee (1945), who summarized the economic effect of mosquito control work in New Jersey. Here property valuations from 1915 to 1930 had increased by $555,345,000.00 over what was expected for those communities that had received mosquito control work. Property values form an essential part of the revenue stream for government services such as schools, police, fire, libraries, parks, and health and welfare programs.

Fourth, the cost of hiring private contractors to provide vector control services on a site-specific basis can end up more costly than the costs associated with the current program (with economies of scale). More significant are the costs associated with having to reestablish a program that has been eliminated. These costs include equipment, staffing, staff training, and the initial environmental costs associated with a new program working to restore vector levels to the healthful level that existed with the old program prior to its elimination. A loss of institutional memory and understanding of local vector populations, their habitats, and the local citizenry cannot be replaced when a program is eliminated. When a program is reestablished, less environmentally friendly measures will be employed during a period of time to bring vector populations down to a level where maintenance and control measures that have little or no environmental impact can be effectively employed (e.g., New York and West Nile virus).

4.1.3 Environmental Conditions

The environmental issues associated with the No Project Alternative cannot be understated. First, in the absence of organized mosquito and vector control programs, unlicensed individuals could begin applying over the counter pesticides on their own. Most of these individuals have little or no training in the proper and effective use of these materials, meaning a reasonable possibility exists of over- or under-application as well as the potential for creation of unrecognized resistance issues. This possibility is especially true for the indiscriminate use of aerosol foggers as well as concentrated pesticides that require mixing with water prior to application. Additionally, the health and well-being of sensitive individuals (e.g., asthmatics and chemically sensitive people) and their pets (especially birds and fish) could be affected by the unexpected drift of these pesticides into their yards, open windows, and neighborhood parks.

Second, the potential exists for increased use of inappropriate or unregistered materials such as bleach, oil, gasoline, diesel fuel, etc., in an effort to deal with vectors, especially mosquitoes and yellow jackets. Their use can cause significant environmental harm compared to materials applied in accordance with label requirements by trained, licensed professionals.

Third, many members of the public lack a general understanding of IPM practices and procedures. Therefore, increased vector-human interactions could lead to the increased use of non-IPM practices to provide rapid relief from vector bites and stings as well as address any fears concerning reports in the media of increased vector-borne disease.

Fourth, as mentioned earlier, some vector-borne diseases such as West Nile virus pose a risk to native bird species, including some species of concern such as yellow-billed magpies, hawks, and owls (Crosbie et al. 2008; Fitzsimmons 2013; LaDeau et al. 2007; Nemeth et al. 2007, 2009; Sovada et al. 2008).

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[To be completed with full citations. Attract and Kill and Mass Trapping citations to be added.]

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Integrated Vector
Management Program

APPENDIX F

SUPPLEMENTAL IVMP INFORMATION

CALIFORNIA MOSQUITO-BORNE VIRUS SURVEILLANCE & RESPONSE PLAN

Edmund G. Brown Jr., Governor

California Department of Public Health
Mosquito & Vector Control Association of California
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April 2013

CALIFORNIA MOSQUITO-BORNE VIRUS SURVEILLANCE AND RESPONSE PLAN

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Objectives

The California Mosquito-borne Virus Surveillance and Response Plan was developed to meet several objectives. Specifically, the Plan:

- Provides guidelines and information on the surveillance and control of mosquito-borne viruses in California, including West Nile, St. Louis encephalitis, and western equine encephalomyelitis viruses;
- Incorporates surveillance data into risk assessment models;
- Prompts surveillance and control activities associated with virus transmission risk level;
- Provides local and state agencies with a decision support system; and
- Outlines the roles and responsibilities of local and state agencies involved with mosquito-borne virus surveillance and response.

This document provides statewide guidelines, but can be modified to meet local or regional conditions.

Introduction

California has a comprehensive mosquito-borne disease surveillance program that has monitored mosquito abundance and mosquito-borne virus activity since 1969 (Reeves et al. 1990) and is an integral part of integrated mosquito management programs conducted by local mosquito and vector control agencies. Surveillance and interagency response guidelines have been published previously by the California Department of Public Health formerly known as the California Department of Health Services (Walsh 1987) and the Mosquito and Vector Control Association of California (Reisen 1995). The detection of West Nile virus (WNV) in New York, a virus not recognized in the Western Hemisphere prior to 1999, prompted the review and enhancement of existing guidelines to ensure that surveillance, prevention, and control activities were appropriate for WNV. From New York, WNV spread rapidly westward and by 2004 had been detected in all 48 of the continental United States. In addition to WNV, California is vulnerable to introduction of other highly virulent mosquito-borne viruses of public and veterinary health concern, such as Japanese encephalitis, dengue, yellow fever, Rift Valley fever, chikungunya and Venezuelan encephalitis viruses. If an existing or introduced virus is detected, it is critical that local and state agencies are prepared to respond in a concerted effort to protect people and animals from infection and disease. The current document describes an enhanced surveillance and response program for mosquito-borne viruses in the State of California. Its contents represent the collective effort of the California Department of Public Health (CDPH), the Mosquito and Vector Control Association of California (MVCAC), and the University of California at Davis (UCD).

Background

Mosquito-borne viruses belong to a group of viruses commonly referred to as arboviruses (for **ar**thropod-**bo**rne). Although 12 mosquito-borne viruses are known to occur in California, only WNV, western equine encephalomyelitis virus (WEE) and St. Louis encephalitis virus (SLE) are significant causes of human disease. WNV continues to seriously impact the health of humans, horses, and wild birds throughout the state. Since 2004, there have been 3,622 WNV human cases with 129 deaths and 1,188 horse cases. Consequently, the California Arbovirus Surveillance Program emphasizes forecasting and monitoring the temporal and spatial activity of

WNV, WEE, and SLE. These viruses are maintained in wild bird-mosquito cycles that do not depend upon infections of humans or domestic animals to persist. Surveillance and control activities focus on this maintenance cycle, which involves primarily *Culex* mosquitoes, such as the western encephalitis mosquito, *Culex tarsalis*, and birds such as house finches and house sparrows.

Immature stages (called larvae and pupae) of *Culex tarsalis* can be found throughout California in a wide variety of aquatic sources, ranging from clean to highly polluted waters. Most such water is associated with irrigation of agricultural crops or urban wastewater. Other mosquito species, such as *Culex pipiens, Culex quinquefasciatus*, and *Culex stigmatosoma*, play an important role in WNV, and possibly SLE, transmission cycles in urban and suburban areas. Historically, *Aedes melanimon*, a floodwater mosquito, played a role in a secondary transmission cycle of WEE involving rabbits. Additional mosquitoes such as *Aedes vexans* and *Culex erythrothorax* also could be important bridge (i.e. bird to mammal) vectors in transmission.

Mosquito control is the only practical method of protecting the human population from infection. There are no known specific treatments or cures for diseases caused by these viruses and vaccines are not available for public use. Infection by WEE virus tends to be most serious in very young children, whereas infections caused by WN and SLE viruses affect the elderly most seriously. WNV also kills a wide variety of native and non-native birds. There are WEE and WNV vaccines available to protect horses since both viruses can cause severe disease in horses. Mosquito-borne disease prevention strategies must be based on a well-planned integrated pest management (IPM) program that uses real-time surveillance to detect problem areas, focus control, and evaluate operational efficacy. The primary components of an IPM program include education, surveillance, and mosquito control.

Education

Residents, farmers, and duck club owners can play an important role in reducing the number of adult mosquitoes by eliminating standing water that may support the development of immature mosquitoes. For instance, residents can help by properly disposing of discarded tires, cans, or buckets; emptying plastic or unused swimming pools; and unclogging blocked rain gutters around homes or businesses. Farmers and ranchers can be instructed to use irrigation practices that do not allow water to stand for extended periods, and duck club owners can work with mosquito control agencies to determine optimal flooding schedules. Educating the general public to curtail outdoor activities during peak mosquito biting times, use insect repellents, and wear long-sleeved clothing will help reduce exposure to mosquitoes. Clinical surveillance is enhanced through education of the medical and veterinary communities to recognize the symptoms of WEE, SLE, and WNV and to request appropriate laboratory tests. Public health officials need to be alerted if a mosquito-borne viral disease case is detected, especially if the public health risk is high.

Surveillance

Surveillance includes the monitoring, visualization, and analysis of data on climatic factors, immature and adult mosquito abundance, and virus activity measured by testing mosquitoes, sentinel chickens, wild birds (including dead birds for WNV), horses, and humans for evidence

of infection. Surveillance must focus not only on mosquito-borne viruses known to exist in California, but be sufficiently broad to also detect newly introduced viruses.

Climate Variation

The California Mediterranean climate provides ideal opportunities for forecasting mosquito abundance and arbovirus activity, because most precipitation falls during winter, as rain at lower elevations or as snow at higher elevations. Spring and summer temperatures then determine the rate of snow melt and runoff, mosquito population growth, the frequency of blood feeding, the rate of virus development in the mosquito, and therefore the frequency of virus transmission. In general, WEE virus outbreaks have occurred in the Central Valley when wet winters are followed by warm summers, whereas SLE and WN virus outbreaks seemed linked to warm dry conditions that lead to large populations of urban *Culex*. Although climate variation may forecast conditions conducive for virus amplification, a critical sequence of events is required for amplification to reach outbreak levels.

Mosquito Abundance

Mosquito abundance can be estimated through collection of immature or adult mosquitoes. The immature stages (larvae and pupae) can be collected from water sources where mosquitoes lay their eggs. A long-handled ladle (“dipper”) is used to collect water samples and the number of immature mosquitoes per "dip" estimated. In most local mosquito control agencies, technicians search for new sources and inspect known habitats for mosquitoes on a 7 to 14-day cycle. These data are used to direct control operations. Maintaining careful records of immature mosquito occurrence and abundance, developmental stages treated, source sizes, and control effectiveness can be useful for estimating the expected sizes of future adult populations.

Adult mosquito abundance is a key factor contributing to the risk of virus transmission. Monitoring the abundance of adult mosquito populations provides important information on the size of the vector population as it responds to changing climatic factors and to control efforts. Four adult mosquito sampling methods are currently used in California: New Jersey light traps, carbon dioxide-baited traps, gravid female traps, and resting adult mosquito collections. The advantages and disadvantages of these sampling methods, and guidelines for the design, operation, and processing of the traps have been discussed in Guidelines for Integrated Mosquito Surveillance (Meyer et al. 2003) and are summarized in Appendix A.

Mosquito Infections

Virus activity can be monitored by testing adult mosquitoes for virus infection. Because *Culex tarsalis* is the primary rural vector of WNV, SLE, and WEE, and *Culex quinquefasciatus* and *Culex pipiens* are important urban vectors of WNV and SLE, surveillance efforts emphasize the testing of these species. Another species that should be tested is *Culex stigmatosoma*, which is a highly competent but less widely distributed vector of WNV and SLE that feeds on birds and is probably important in enzootic transmission where it is found in high abundance. Female mosquitoes are trapped, usually using carbon dioxide-baited or gravid traps, identified to species, and counted into groups (pools) of 50 females each for testing at the Center for Vectorborne Diseases (CVEC) at UC Davis or by local agencies that pass annual proficiency testing. Procedures for submitting and processing mosquitoes for detecting virus infection are detailed in

Appendix B. The current surveillance system is designed to detect and measure levels of infection with WNV, SLE, and WEE. Although generally less sensitive than sentinel chickens, mosquito infections may be detected earlier in the season and over a finer scale than chicken seroconversions and therefore provide an early warning of virus activity. Testing adult mosquitoes for infection is one of the best methods to detect newly introduced or emerging mosquito-borne viruses. Testing mosquito species other than *Culex* may be necessary to detect the introduction of viruses that do not have a primary avian-*Culex* transmission cycle.

Avian Infections

Detection of arboviral transmission within bird populations can be accomplished by 1) using caged chickens as sentinels and bleeding them routinely to detect viral antibodies (seroconversions), 2) collecting and bleeding wild birds to detect viral antibodies (seroprevalence), and 3) testing dead birds reported by the public for WNV.

In California, flocks of 5-10 chickens are placed in locations where mosquito abundance is known to be high or where there is a history of virus activity. Each chicken is bled every two weeks by pricking the comb and collecting blood on a filter paper strip. The blood is tested at the CDPH Vector-Borne Disease Section for antibodies to SLE, WEE, and WNV. Some agencies conduct their own testing, but send positive samples to CDPH for confirmation and official reporting. Because SLE cross-reacts with WNV in antibody testing, SLE or WNV positive chickens are confirmed and the infecting virus is identified by western blot or cross-neutralization tests. Frequent testing of strategically placed flocks of sentinel chickens provides the most sensitive and cost-effective method to monitor encephalitis virus transmission in an area. Because chickens are continuously available to host-seeking mosquitoes, they are usually exposed to more mosquitoes than can be collected by trapping, especially when adult mosquito abundance or viral infection rates are low. Sentinel housing, bleeding instructions, and testing protocols are provided in Appendix C.

Virus activity in wild bird populations can be monitored by bleeding young (hatching year) birds to detect initial virus infection or by bleeding a cross-section of birds in an area and comparing seroprevalence among age strata to determine if the prevalence of the virus in the region has changed. Elevated seroprevalence levels ("herd immunity") among key species during spring may limit virus transmission and dampen amplification. New infections also can be detected by bleeding banded birds in a capture-recapture scheme. In contrast to the convenience of using sentinel chickens, the repeated collection and bleeding of wild birds generally is too labor intensive, technically difficult, and expensive for most local mosquito control agencies to perform routinely. In addition, the actual place where a wild bird became infected is rarely known, because birds may travel over relatively long distances and usually are collected during daylight foraging flights and not at nighttime roosting sites where they are bitten by mosquitoes.

Unlike WEE and SLE, WNV frequently causes death in North American birds, especially those in the family Corvidae (e.g. crows, ravens, magpies, jays). Dead bird surveillance was initiated by CDPH in 2000 to provide early detection of WNV. Dead bird surveillance has been shown to be one of the earliest indicators of WNV activity in a new area. Birds that meet certain criteria are necropsied at the California Animal Health and Food Safety Laboratory and kidney snips tested for WNV RNA by RT-PCR at CVEC or oral swabs of American crows tested by rapid antigen tests by local agencies. Dead birds are reported to CDPH's dead bird hotline (1-877-

WNV-BIRD) or via the website, http://westnile.ca.gov. Beginning in 2010, results from RT-PCR testing at CVEC distinguished between WNV recent and chronic positive birds based on qRT-PCR cycle threshold (Ct) values. In general, birds tested by RT-PCR with a Ct value of <30 and those positive by antigen tests are considered to be recently infected, whereas those with Ct values >30 are considered to have been chronically infected and the time since infection unknown. Chronic positive birds did not likely die from WNV infection and are of limited value for surveillance. The communication and testing algorithm for the dead bird surveillance program is detailed in Appendix D.

Tree Squirrel Infections

In 2004, tree squirrels were included as a WNV surveillance tool, based upon evidence that they were susceptible to WNV and could provide information on localized WNV transmission (Padgett et al. 2007). In conjunction with dead birds, tree squirrels were reported to the California WNV hotline, necropsied at the California Animal Health and Food Safety Laboratory and kidney tissue was tested by RT-PCR at CVEC. Tree squirrels will continue to be tested for WNV in 2013 and are included in the submission protocol in Appendix D.

Equine Infections

Currently, equine disease due to WEE and WNV is no longer a sensitive indicator of epizootic activity (unusually high incidence of infections in animals other than humans) in California because of the widespread vaccination or natural immunization of equids (horses, donkeys, and mules). Nevertheless, confirmed cases in horses can indicate that WEE or WNV has amplified to levels where tangential transmission has occurred and risk to humans is elevated in that region of the state. Each year, CDPH and the California Department of Food and Agriculture (CDFA) alert veterinarians to the risk of WNV in horses, advocate for vaccination, and provide information on diagnostic services that are available for suspected cases of WEE or WNV encephalitis. Numerous infectious and non-infectious causes, including other mosquito-borne viruses, can contribute to encephalitis and neurologic signs in horses. Testing of equine specimens for these possible etiologies is available through the California Animal Health and Food Safety Laboratory (see Appendix E).

Human Infections

Local mosquito control agencies rely on the rapid detection and reporting of confirmed human cases to plan and implement emergency control activities to prevent additional infections. However, human cases of arboviral infection are an insensitive surveillance indicator of virus activity because most persons who become infected develop no symptoms. For those individuals who do become ill, it may take up to two weeks for symptoms to appear, followed by additional time until the case is recognized and reported. No human cases of SLE or WEE have been reported in California in recent years. However, a total of 3,625 cases of WNV have been reported in California from 2003-2012.

To enhance human WNV testing and surveillance efforts throughout the state, a regional public health laboratory network was established in 2002. The laboratory network consists of the state Viral and Rickettsial Disease Laboratory (VRDL) as well as 20 county public health laboratories that are able to conduct WNV testing. Providers are encouraged to submit specimens for suspect

WNV cases to their local public health laboratories. Specimens for patients with encephalitis may also be submitted directly to Neurologic Surveillance and Testing, which is based in the VRDL and offers diagnostic testing for many agents known to cause encephalitis, including WNV and other arboviruses. In addition, VRDL collaborates with reference laboratories such as the regional laboratories of Kaiser Permanente to ascertain additional suspect WNV cases.

In accordance with Title 17 of the California Code of Regulations (Sections 2500 and 2505), physicians and laboratories are required to report cases of WNV infection or positive test results to their local health department. Positive WNV or other arbovirus test results are investigated by local health department officials to determine whether a patient meets the clinical and laboratory criteria for a WNV diagnosis. If so, the local health department collects demographic and clinical information on the patient using a standardized WNV infection case report, and forwards the report to the state health department. The local health department also determines whether the infection was acquired locally, imported from a region outside the patient's residence, or acquired by a non-mosquito route of transmission such as blood transfusion or organ transplantation. Appendix F contains the protocol for submission of specimens to the regional public health laboratory network for WNV testing. Appendix G provides the national surveillance case definition for WNV infection.

Mosquito Control

Problems detected by surveillance are mitigated through larval and adult mosquito control. Mosquito control is the only practical method of protecting people from mosquito-borne diseases. Mosquito control in California is conducted by approximately 80 local agencies, including mosquito and vector control districts, county environmental and health departments, and county agriculture departments. Agencies applying pesticides directly to a water of the United States, or where deposition may enter a water of the United States, must obtain a National Pollutant Discharge Elimination System (NPDES) Permit for Biological and Residual Pesticide Discharges to Waters of the United States from Vector Control Applications (Vector Control Permit). Agencies must comply with provisions of the permit, including use of approved pesticides, pesticide use reporting, and visual, chemical, and toxicity monitoring requirements included in the permit. http://www.swrcb.ca.gov/water_issues/programs/npdes/aquatic.shtml

Compounds currently approved for larval and adult mosquito control in California are listed in Appendix H. Please refer to the Vector Control Permit, Attachments E and F, for a list of vector control pesticides that may be applied to waters of the United States, unless the receiving water has an existing impairment from a pesticide with the same active ingredient. Please review the California State Water Resources Control Board listing of impaired water bodies (303d list) prior to applying any pesticide.
http://www.swrcb.ca.gov/rwqcb4/water_issues/programs/303d_list.shtml

Additional considerations regarding adult mosquito control in urban areas are described in Appendix I.

Larval Control

Mosquito larval and pupal control methods are target-specific and prevent the emergence of adult female mosquitoes which are capable of transmitting pathogens, causing discomfort, and

ultimately producing another generation of mosquitoes. For these reasons, most mosquito control agencies in California target the immature stages rather than the adult stage of the mosquito. Larval mosquito control has three key components: environmental management, biological control, and chemical control.

Environmental management decreases habitat availability or suitability for immature mosquitoes, and may include water management, such as increasing the water disposal rate through evaporation, percolation, recirculation, or drainage. Laser-leveling of fields minimizes pooling at low spots, allows even distribution of irrigation water, and precludes standing water for long periods. Controlled irrigation or the careful timing of wetland flooding for waterfowl can reduce mosquito production or limit emergence to times of the year when virus activity is unlikely. Environmental management may include vegetation management because emergent vegetation provides food and refuge for mosquito larvae. Management strategies include the periodic removal or thinning of vegetation, restricting growth of vegetation, and controlling algae.

Biological control uses natural predators, parasites, or pathogens to reduce immature mosquito numbers. Mosquitofish, *Gambusia affinis*, are the most widely used biological control agent in California. These fish are released annually in a variety of habitats, such as rice fields, small ponds, and canals.

There are several mosquito control products that are highly specific and thus have minimal impact on non-target organisms. These include microbial control agents, such as *Bacillus thuringiensis israelensis* (Bti) and *Bacillus sphaericus*, and insect growth regulators, such as methoprene, that prevent immature mosquitoes from developing into adults. Surface films are very effective against both larvae and pupae, but also may suffocate other surface breathing aquatic insects. Organophosphate pesticides are used infrequently because of their impact on nontarget organisms and the environment.

Adult Control

When larval control is not possible or more immediate control measures are needed, adult mosquito control may be required to suppress populations of infected mosquitoes and interrupt epidemic virus transmission. Adult mosquito control products may be applied using ground-based equipment, fixed wing airplanes, or helicopters. Products applied in ultralow volume [ULV] formulations and dosages include organophosphates, such as malathion and naled, pyrethroids, such as resmethrin, sumithrin, and permethrin, and pyrethrins such as Pyrenone crop spray. Factors to consider when selecting an adulticide include: 1) efficacy against the target species or life cycle stage, 2) resistance status, 3) pesticide label requirements, 4) availability of pesticide and application equipment, 5) environmental conditions, 6) cost, and 7) toxicity to nontarget species, including humans.

For more information about mosquito control please see "Best Management Practices for Mosquito Control in California". http://www.westnile.ca.gov/resources.php

Response Levels

The California Mosquito-borne Virus Surveillance and Response Plan was developed to provide a semi-quantitative measure of virus transmission risk to humans that could be used by local mosquito control agencies to plan and modulate control activities. Independent models are presented for WEE, SLE and WNV to accommodate the different ecological dynamics of these viruses (Barker et al. 2003). SLE and WN viruses are closely related, require similar environmental conditions, and employ the same *Culex* vectors. Seven surveillance factors are measured and analyzed to determine the level of risk for human involvement and thereby gauge the appropriate response level:

1. Environmental or climatic conditions (snowpack, rainfall, temperature, season)
2. Adult *Culex* vector abundance
3. Virus infection rate in *Culex* mosquito vectors
4. Sentinel chicken seroconversions
5. Fatal infections in birds (WNV only)
6. Infections in humans
7. Proximity of detected virus activity to urban or suburban regions (WEE only)

Each factor is scored on an ordinal scale from 1 (lowest risk) to 5 (highest risk). The mean score calculated from these factors corresponds to a response level as follows: normal season (1.0 to 2.5), emergency planning (2.6 to 4.0), and epidemic (4.1 to 5.0). Table 1 provides a worksheet to assist in determining the appropriate rating for each of the risk factors for each of the three viruses. Appendix J shows sources of data useful in the calculation of risk in Table 1. Surveillance data can be managed and risk level calculated in time and space using the Surveillance Gateway.

For surveillance factor 2 (vector abundance), abundance is expressed as a percentage of normal by comparing the current level for an area to the average over the previous 5 years for the same two-week period. An "area" typically encompasses the boundaries of a local mosquito and vector control district but could represent a smaller unit if desired. Mosquitoes' virus infection rate should be calculated using the most recent data (prior two week period) and expressed as the minimum infection rate (MIR) per 1,000 female mosquitoes tested. Calculations may also use maximum likelihood estimates (Centers for Disease Control and Prevention 2011), which account for varying numbers of specimens in pools and the possibility that more than one mosquito could be infected in each positive pool when infection rates are high. For WNV and SLE, risk may be estimated separately for *Cx. tarsalis* and the *Cx. pipiens* complex, respectively, because these species generally have different habitat requirements and therefore spatial distributions (e.g., rural vs. urban).

Each of the three viruses differs in its response to ecological conditions. WEE activity typically is greatest during El Niño conditions of wet winters, excessive run-off and flooding, cool springs, and increased *Culex tarsalis* abundance. Historically, WEE virus spillover into a secondary *Aedes*-rabbit cycle was common in the Central Valley, but has not been detected for more than 25 years. In contrast, SLE and perhaps WNV activity appears to be greatest during La Niña conditions of drought and hot summer temperatures and both SLE and WNV transmission risk increases when temperatures are above normal. Abundance and infection of the *Culex pipiens* complex are included in both SLE and WNV estimates of risk because these mosquito species are important vectors, particularly in suburban/urban environments. The occurrence of dead bird infections is included as a risk factor in the WNV calculations. For surveillance

factors 4-6 (chickens, birds, humans), the specific region is defined as the area within the agency's boundary and the broad region includes the area within 150 miles (~241 km) of the agency's boundary.

Proximity of virus activity to human population centers is considered an important risk factor for all three viruses of public health concern. In the risk assessment model in Table 1 this was accommodated in two different ways. WEE virus transmitted by *Culex tarsalis* typically amplifies first in rural areas and may eventually spread into small and then larger communities. A risk score was included to account for where virus activity was detected. WNV and SLE virus may be amplified concurrently or sequentially in rural and urban cycles. The rural cycle is similar to WEE virus and is transmitted primarily by *Cx. tarsalis*, whereas the urban cycle is transmitted primarily by members of the *Culex pipiens* complex. If the spatial distributions of key *Culex* species differ within an area (e.g., rural vs. urban), it may be advantageous to assess risk separately by species for abundance and infection rates in *Cx. tarsalis* and the *Cx. pipiens* complex. This would result in two estimates of overall risk for the areas dominated by each species.

Each of these surveillance factors can differ in impact and significance according to time of year and geographic region. Climate is used prospectively to forecast risk during the coming season. Climatic factors provide the earliest indication of the potential for increased mosquito abundance and virus transmission and constitute the only risk factor actually measured from the start of the calendar year through mid-spring when enzootic surveillance commences in most areas. Other factors that may inform control efforts as the season progresses are typically, in chronological order: mosquito abundance, infections in non-humans (e.g., dead birds for WNV, mosquitoes, sentinel chickens), and infections in humans. Enzootic indicators measure virus amplification within the *Culex*-bird cycle and provide nowcasts of risk, whereas human infections document tangential transmission and are the outcome measure of forecasts and nowcasts. Response to the calculated risk level should consider the time of year; e.g., epidemic conditions in October would warrant a less aggressive response compared to epidemic conditions in July because cooler weather in late fall will contribute to declining risk of arbovirus transmission.

The ratings listed in Table 1 are benchmarks only and may be modified as appropriate to the conditions in each specific region or biome of the state. Calculation and mapping of risk has been enabled by tools included in the CalSurv Gateway. Roles and responsibilities of key agencies involved in carrying out the surveillance and response plan are outlined in "Key Agency Responsibilities."

Table 1. Mosquito-borne Virus Risk Assessment.

WNV Surveillance Factor	Assessment Value	Benchmark	Assigned Value	
1. Environmental Conditions High-risk environmental conditions include above-normal temperatures with or without above-normal rainfall, runoff, or snowpack. Weather data link: http://ipm.ucdavis.edu	1	Avg daily temperature during prior 2 weeks ≤ 56 °F		
	2	Avg daily temperature during prior 2 weeks 57 – 65 °F		
	3	Avg daily temperature during prior 2 weeks 66 – 72 °F		
	4	Avg daily temperature during prior 2 weeks 73 – 79 °F		
	5	Avg daily temperature during prior 2 weeks > 79 ° F		
			Cx tars	*Cx pip*
2. **Adult *Culex tarsalis* and *Cx. pipiens* complex relative abundance*** Determined by trapping adults, enumerating them by species, and comparing numbers to those previously documented for an area for the prior 2-week period.	1	Vector abundance well below average (≤ 50%)		
	2	Vector abundance below average (51 - 90%)		
	3	Vector abundance average (91 - 150%)		
	4	Vector abundance above average (151 - 300%)		
	5	Vector abundance well above average (> 300%)		
3. **Virus infection rate in *Culex tarsalis* and *Cx. pipiens* complex mosquitoes*** Tested in pools of 50. Test results expressed as minimum infection rate per 1,000 female mosquitoes tested (MIR) for the prior 2-week period.	1	MIR = 0		
	2	MIR = 0.1 - 1.0		
	3	MIR = 1.1 - 2.0		
	4	MIR = 2.1 - 5.0		
	5	MIR > 5.0		
4. **Sentinel chicken seroconversion** Number of chickens in a flock that develop antibodies to WNV during the prior 2-week period. If more than one flock is present in a region, number of flocks with seropositive chickens is an additional consideration. Typically 10 chickens per flock.	1	No seroconversions in broad region		
	2	One or more seroconversions in broad region		
	3	One or two seroconversions in a single flock in specific region		
	4	More than two seroconversions in a single flock or two flocks with one or two seroconversions in specific region		
	5	More than two seroconversions per flock in multiple flocks in specific region		
5. **Dead bird infection** Number of birds that have tested positive (recent infections only) for WNV during the prior 3-month period. This longer time period reduces the impact of zip code closures during periods of increased WNV transmission.	1	No positive dead birds in broad region		
	2	One or more positive dead birds in broad region		
	3	One positive dead bird in specific region		
	4	Two to five positive dead birds in specific region		
	5	More than five positive dead birds in specific region		
6. **Human cases** Do not include this factor in calculations if no cases are detected in region.	3	One or more human infections in broad region		
	4	One human infection in specific region		
	5	More than one human infection in specific region		
			Cx tars	*Cx pip*
<u>Response Level / Average Rating:</u> Normal Season (1.0 to 2.5) Emergency Planning (2.6 to 4.0) Epidemic (4.1 to 5.0)		**TOTAL**		
		AVERAGE		

* Calculation of separate risk values for *Cx. tarsalis* and the *Cx. pipiens* complex may be useful if their spatial distributions (e.g., rural vs. urban) differ within the assessment area.

SLE Surveillance Factor	Assessment Value	Benchmark	Assigned Value	
1. Environmental Conditions High-risk environmental conditions include above-normal temperatures with or without above-normal rainfall, runoff, or snowpack. Weather data link: http://ipm.ucdavis.edu	1	Avg daily temperature during prior 2 weeks ≤ 56 °F		
	2	Avg daily temperature during prior 2 weeks 57 – 65 °F		
	3	Avg daily temperature during prior 2 weeks 66 – 72 °F		
	4	Avg daily temperature during prior 2 weeks 73 – 79 °F		
	5	Avg daily temperature during prior 2 weeks > 79 ° F		
			Cx tars	*Cx pip*
2. **Adult *Culex tarsalis* and *Cx. pipiens* complex relative abundance*** Determined by trapping adults, enumerating them by species, and comparing numbers to those previously documented for an area for the prior 2-week period.	1	Vector abundance well below average (≤ 50%)		
	2	Vector abundance below average (51 - 90%)		
	3	Vector abundance average (91 - 150%)		
	4	Vector abundance above average (151 - 300%)		
	5	Vector abundance well above average (> 300%)		
3. **Virus infection rate in *Culex tarsalis* and *Cx. pipiens* complex mosquitoes*** Tested in pools of 50. Test results expressed as minimum infection rate per 1,000 female mosquitoes tested (MIR) for the prior 2-week collection period.	1	MIR = 0		
	2	MIR = 0.1 - 1.0		
	3	MIR = 1.1 - 2.0		
	4	MIR = 2.1 - 5.0		
	5	MIR > 5.0		
4. **Sentinel chicken seroconversion** Number of chickens in a flock that develop antibodies to SLEV during the prior 2-week period. If more than one flock is present in a region, number of flocks with seropositive chickens is an additional consideration. Typically 10 chickens per flock.	1	No seroconversions in broad region		
	2	One or more seroconversions in broad region		
	3	One or two seroconversions in a single flock in specific region		
	4	More than two seroconversions in a single flock or two flocks with one or two seroconversions in specific region		
	5	More than two seroconversions per flock in multiple flocks in specific region		
5. **Human cases** Do not include this factor in calculations if no cases are detected in region.	3	One or more human cases in broad region		
	4	One human case in specific region		
	5	More than one human case in specific region		
			Cx tars	*Cx pip*
Response Level / Average Rating: Normal Season (1.0 to 2.5) Emergency Planning (2.6 to 4.0) Epidemic (4.1 to 5.0)		**TOTAL**		
		AVERAGE		

* Calculation of separate risk values for *Cx. tarsalis* and the *Cx. pipiens* complex may be useful if their spatial distributions (e.g., rural vs. urban) differ within the assessment area.

WEE Surveillance Factor	Assessment Value	Benchmark	Assigned Value
1. **Environmental Conditions** High-risk environmental conditions include above normal rainfall, snow pack, and runoff during the early season followed by a strong warming trend. Weather data link: http://ipm.ucdavis.edu	1	Cumulative rainfall and runoff well below average	
	2	Cumulative rainfall and runoff below average	
	3	Cumulative rainfall and runoff average	
	4	Cumulative rainfall and runoff above average	
	5	Cumulative rainfall and runoff well above average	
2**. Adult *Culex tarsalis* abundance** Determined by trapping adults, enumerating them by species, and comparing numbers to averages previously documented for an area for the prior 2-week period.	1	*Cx. tarsalis* abundance well below average (≤ 50%)	
	2	*Cx. tarsalis* abundance below average (51 - 90%)	
	3	*Cx. tarsalis* abundance average (91 - 150%)	
	4	*Cx. tarsalis* abundance above average (151 - 300%)	
	5	*Cx. tarsalis* abundance well above average (> 300%)	
3. **Virus infection rate in *Cx. tarsalis* mosquitoes** Tested in pools of 50. Test results expressed as minimum infection rate per 1,000 female mosquitoes tested (MIR) for the prior 2-week collection period.	1	*Cx. tarsalis* MIR = 0	
	2	*Cx. tarsalis* MIR = 0.1 - 1.0	
	3	*Cx. tarsalis* MIR = 1.1 - 2.0	
	4	*Cx. tarsalis* MIR = 2.1 - 5.0	
	5	*Cx. tarsalis* MIR > 5.0	
4. **Sentinel chicken seroconversion** Number of chickens in a flock that develop antibodies to WEEV during the prior 2-week period. If more than one flock is present in a region, number of flocks with seropositive chickens is an additional consideration. Typically 10 chickens per flock.	1	No seroconversions in broad region	
	2	One or more seroconversions in broad region	
	3	One or two seroconversions in a single flock in specific region	
	4	More than two seroconversions in a single flock or two flocks with one or two seroconversions in specific region	
	5	More than two seroconversions per flock in multiple flocks in specific region	
5. **Proximity to urban or suburban regions** (score only if virus activity detected) Risk of outbreak is highest in urban areas because of high likelihood of contact between humans and vectors.	1	Virus detected in rural area	
	3	Virus detected in small town or suburban area	
	5	Virus detected in urban area	
6. **Human cases** Do not include this factor in calculations if no cases found in region or in agency.	3	One or more human cases in broad region	
	4	One human case in specific region	
	5	More than one human case in specific region	
<u>Response Level / Average Rating:</u> Normal Season (1.0 to 2.5) Emergency Planning (2.6 to 4.0) Epidemic (4.1 to 5.0)		**TOTAL**	
		AVERAGE	

General suggestions for applying the risk assessment model locally

- Use a consistent time period for environmental conditions, adult mosquito abundance, mosquito infection rates, and human cases. If you use a period that differs from the prior two-week period defined in the risk assessment -- such as the prior month -- use the same period for all other relevant measures. Note that sentinel seroconversions and dead bird infections may need special treatment to accommodate bleeding schedules and zip code closures, respectively. For sentinel seroconversions, use data from the most recent collection.
- If you have multiple trap types in your surveillance program, determine the vector abundance anomaly for each trap type and species and use the most sensitive trap type's value in the risk assessment.
- When determining the vector abundance anomaly, there should be at least two and preferably five years of prior data to provide a comparative baseline for the particular trap type. Ideally, the prior years should use the same or very similar trap locations and be contiguous and immediately precede the time period being evaluated.

Risk assessment as implemented by the CalSurv Gateway (http://gateway.calsurv.org)

- Statewide maps at a resolution of 1 km^2 will be generated and delivered to the primary contacts of each agency by email every Monday.
- Only those agencies with active Gateway accounts and defined primary contacts will receive the weekly maps.
- Mapped risk surfaces are generated for all areas of California that have one or more surveillance inputs within 8 km. The risk for each pixel in the map image is based on a spatially weighted summary of all available surveillance data within 8 km. Pixels > 8 km from the nearest surveillance do not have assigned risk values.
- Due to privacy concerns and delays in detection and reporting, human cases are not part of the Gateway's risk assessment.
- All of the general suggestions from the prior section are used in the Gateway's implementation.
- Risk estimates based on mosquito abundance and infection rates will be calculated separately for the key mosquito taxa, *Cx. tarsalis* and the *Cx. pipiens* complex.
- The risk assessment model is implemented also in an online calculator for use by local vector control agencies that allows user definition of locations and date ranges for calculation.

Characterization of Conditions and Responses

Level 1: Normal Season

Risk rating: 1.0 to 2.5

CONDITIONS
• Average or below average snowpack and rainfall; below or average seasonal temperatures (<65F) • *Culex* mosquito abundance at or below five year average (key indicator = adults of vector species) • No virus infection detected in mosquitoes • No seroconversions in sentinel chickens • No recently infected WNV-positive dead birds • No human cases
RESPONSE
• Conduct routine public education (eliminate standing water around homes, use personal protection measures) • Conduct routine mosquito and virus surveillance activities • Comply with National Pollutant Discharge Eliminations System (NPDES) permit if applying pesticides to waters of the United States • Conduct routine mosquito control, with emphasis on larval control • Inventory pesticides and equipment • Evaluate pesticide resistance in vector species • Ensure adequate emergency funding • Release routine press notices • Send routine notifications to physicians and veterinarians • Establish and maintain routine communication with local office of emergency services personnel; obtain Standardized Emergency Management System (SEMS) training

Level 2: Emergency Planning

Risk rating: 2.6 to 4.0

CONDITIONS
• Snowpack and rainfall and/or temperature above average (66-79F) • Adult *Culex* mosquito abundance greater than 5-year average (150% to 300% above normal) • One or more virus infections detected in *Culex* mosquitoes (MIR / 1000 is <5) • One or more seroconversions in single flock or one to two seroconversions in multiple flocks in specific region • One to five recently infected WNV-positive dead birds in specific region • One human case in broad or specific region • WEE virus detected in small towns or suburban area
RESPONSE
• Review epidemic response plan • Enhance public education (include messages on the signs and symptoms of encephalitis; seek medical care if needed; inform public about pesticide applications if appropriate) • Enhance information to public health providers • Conduct epidemiological investigations of cases of equine or human disease • Increase surveillance and control of mosquito larvae • Increase adult mosquito surveillance • Increase number of mosquito pools tested for virus • Conduct or increase localized chemical control of adult mosquitoes as appropriate • Contact commercial applicators in anticipation of large scale adulticiding • Review candidate pesticides for availability and susceptibility of vector mosquito species • Ensure notification of key agencies of presence of viral activity, including the local office of emergency services

Level 3: Epidemic Conditions

Risk rating: 4.1 to 5.0

CONDITIONS
• Snowpack, rainfall, and water release rates from flood control dams and/or temperature well above average (>79F) • Adult vector population extremely high (>300%) • Virus infections detected in multiple pools of *Culex tarsalis* or *Cx. pipiens* mosquitoes (MIR / 1000 > 5.0) • More than two seroconversions per flock in multiple flocks in specific region • More than five recently infected WNV-positive dead birds and multiple reports of dead birds in specific region • More than one human case in specific region • WEE virus detection in urban or suburban areas
RESPONSE
• Conduct full scale media campaign • Alert physicians and veterinarians to expect cases • Conduct active human case detection • Conduct epidemiological investigations of cases of equine or human disease • Continue enhanced larval surveillance and control of immature mosquitoes • Broaden geographic coverage of adult mosquito surveillance • Accelerate adult mosquito control as appropriate by ground and/or air • Coordinate the response with the local Office of Emergency Services or if activated, the Emergency Operation Center (EOC) • Initiate mosquito surveillance and control in geographic regions without an organized vector control program • Determine whether declaration of a local emergency should be considered by the County Board of Supervisors (or Local Health Officer) • Determine whether declaration of a "State of Emergency" should be considered by the Governor at the request of designated county or city officials • Ensure state funds and resources are available to assist local agencies at their request • Determine whether to activate a Standardized Emergency Management System (SEMS) plan at the local or state level • Continue mosquito education and control programs until mosquito abundance is substantially reduced and no additional human cases are detected

For more detailed information on responding to a mosquito-borne disease outbreak, please refer to:

Operational Plan for Emergency Response to Mosquito-Borne Disease Outbreaks, California Department of Public Health (supplement to California Mosquito-Borne Virus Surveillance and Response Plan). http://www.westnile.ca.gov/resources.php

Key Agency Responsibilities

Local Mosquito and Vector Control Agencies

- Gather, collate, and interpret regional climate and weather data.
- Monitor abundance of immature and adult mosquitoes.
- Collect and submit mosquito pools to CVEC for virus detection.
- Maintain sentinel chicken flocks, obtain blood samples, and send samples to VBDS.
- Pick-up and ship dead birds for necropsy and WNV testing, or test oral swabs from American crows locally via rapid antigen screening assays.
- Update CDPH weekly of all birds that are independently reported and/or tested by VecTOR Test, RAMP or RT-PCR.
- Update the Surveillance Gateway weekly with mosquito pool results that are independently tested by RAMP or RT-PCR.
- Conduct routine control of immature mosquitoes.
- Comply with NPDES permit if applying pesticides to waters of the United States
- Conduct control of adult mosquitoes when needed.
- Educate public on mosquito avoidance and reduction of mosquito breeding sites.
- Coordinate with local Office of Emergency Services personnel.
- Communicate regularly with neighboring agencies

Mosquito and Vector Control Association of California

- Coordinate purchase of sentinel chickens.
- Receive, track, and disburse payment for mosquito surveillance expenses.
- Coordinate surveillance and response activities among member agencies.
- Serve as spokesperson for member agencies.
- Establish liaisons with press and government officials.

California Department of Public Health

- Collate adult mosquito abundance data submitted by local agencies; provide summary of data to local agencies.
- Maintain a WNV information and dead bird reporting hotline, 1-877-WNV-BIRD, and a WNV website: http://westnile.ca.gov.
- Coordinate submission of specimens for virus testing.
- Provide supplies for processing mosquito pool and sentinel chicken diagnostic specimens
- Test sentinel chicken sera for viral antibodies.
- Test human specimens for virus.
- Distribute a weekly bulletin summarizing surveillance test results.
- Send weekly surveillance results to the UC Davis interactive website.
- Immediately notify local vector control agency and public health officials when evidence of viral activity is found.
- Conduct epidemiological investigations of cases of human disease.
- Coordinate and participate in a regional emergency response in conjunction with California Emergency Management Agency.
- Conduct surveillance for human cases.

- Provide oversight to local jurisdictions without defined vector-borne disease control program.
- Maintain inventory of antigens and antisera to detect exotic viruses.
- Provide confirmation of tests done by local agencies.

University of California at Davis

- Conduct research on arbovirus surveillance, transmission of mosquito-borne diseases, and mosquito ecology and control.
- Test mosquito pools and dead birds for endemic and introduced viruses.
- Provide a proficiency panel of tests for identification of viruses from human, equine, bird, or arthropod vectors to local agencies to ensure quality control.
- Maintain an interactive website (http://gateway.calsurv.org) for dissemination of mosquito-borne virus information and data.
- Maintain inventory of antigens, antisera, and viruses to detect the introduction of exotic viruses.
- Provide confirmation of tests done by local or state agencies.

California Department of Food and Agriculture

- Notify veterinarians and veterinary diagnostic laboratories about WEE and WNV and testing available at CAHFS
- Provide outreach to general public and livestock managers of the need to monitor and report equine and ratite encephalitides.
- Facilitate equine and ratite sample submission from veterinarians.
- Conduct investigations of equine confirmed WNV and WEE cases.

California Animal Health and Food Safety Laboratory

- Identify species of dead birds submitted for WNV testing.
- Conduct necropsies and testing on dead birds.
- Submit bird tissues to CVEC for testing.
- Test equine specimens for WNV.

Local Health Departments and Public Health Laboratories

- Test human specimens for WNV.
- Refer human specimens to CDPH for further testing.
- Notify local medical community, including hospitals and laboratories, if evidence of viral activity is present.
- Collect dead birds and ship carcasses to testing laboratories when needed.
- Test American crows via rapid assay or RT-PCR as resources allow.
- Participate in emergency response.
- Conduct epidemiological investigations of cases of human disease.
- Report WNV cases to CDPH.
- Conduct public education.

California Emergency Management Agency

- Coordinate the local, regional, or statewide emergency response under epidemic conditions in conjunction with CDPH via the Standardized Emergency Management System (SEMS).
- Serve as liaison with the Federal Emergency Management Agency (FEMA) in the event that a federal disaster has been declared.

Federal Centers for Disease Control and Prevention

- Provide consultation to state and local agencies in California if epidemic conditions exist.
- Provide national surveillance data to state health departments.

State Water Resources Control Board

- Review NPDES permit applications and respond in a timely manner.
- Review vector control pesticides registered by the California Department of Pesticide Regulation for inclusion on the Vector Control NPDES permit.

Appendix A: Guidelines for Adult Mosquito Surveillance

The objective of Appendix A is to standardize mosquito sampling and reporting procedures to provide comparable and interpretable abundance measures among collaborating mosquito control agencies in California. This section summarizes information from Integrated Mosquito Surveillance Program Guidelines for California that has been adopted by the Mosquito and Vector Control Association (MVCAC) (Meyer et al. 2003). The MVCAC guidelines recommend stratifying the use of different sampling methods in rural, small town, and urban environments for each of the major biomes of California and provide a listing of target vector and nuisance mosquito species. The stratified sampling approach monitors vector populations and virus activity in rural enzootic foci, agricultural or suburban amplification sites, and densely populated urban centers to provide estimates of early, eminent, and current epidemic risk.

The four sampling methods currently used by mosquito control agencies are: 1) New Jersey (American) light trap (Mulhern 1942), 2) CDC/ EVS style, or other CO_2-baited trap (Newhouse et al. 1966; Sudia and Chamberlain 1962), 3) gravid trap (Cummings 1992; Reiter 1983), and 4) adult resting collections (Loomis and Sherman 1959). Collection location sites should be geocoded and registered using the Surveillance Gateway [http://gateway.calsurv.org/]. Studies comparing trap design and efficiency for surveillance purposes have been published (Reisen et al. 2000; Reisen et al. 2002). These guidelines describe: 1) a comparison of the sampling methods, 2) equipment design, 3) operation, 4) specimen processing, 5) data recording and analysis, and 6) data usage.

Advantages and Disadvantages of Mosquito Sampling Methods:

New Jersey Light Trap	
Pros	**Cons**
• All female metabolic states and males collected • Minimal collection effort (can be run nightly without service) • Long history of use in California	• Selective for phototactic nocturnally active mosquitoes • Ineffective in the presence of competing light sources • Sorting time excessive because of other insects in traps • Specimens dead; less useful for virus detection • Collects comparatively few specimens
CDC/EVS CO_2 Trap	
Pros	**Cons**
• Samples biting population • Collects large numbers of virus vector species • Specimens are alive and suitable for virus detection • Without light, collects mostly mosquitoes thus reducing sorting time • Battery operated, portable	• Collects >50% nullipars (females that have never blood fed or laid eggs) • Must be set and picked-up daily • Dry ice cost high; availability can be a problem • Does not collect males or bloodfed and gravid females
Gravid Trap	
Pros	**Cons**
• Collects females that have bloodfed and digested a blood meal; may have higher infection rate than CO_2 trap • Specimens are alive and suitable for virus detection • Extremely sensitive for *Cx.quinquefasciatus and Cx. pipiens* in urban habitats • Bait inexpensive • Battery operated, portable	• Collects only foul-water *Culex* [mostly *pipiens* complex] • Bait has objectionable odor • Must be set and picked-up daily

Resting Catches	
Pros	**Cons**
• All metabolic states collected • Minimal equipment needed • Specimens are alive and suitable for virus detection • Blooded and gravid specimens can be tested to improve sensitivity of virus surveillance	• Standardization is difficult due to: 1. Variable shelter size and type 2. Variable collector efficiency • Labor intensive; difficult to concurrently sample a large number of sites

New Jersey (American) Light Trap (NJLT)

Operation

At a minimum, one trap should be located in each principal municipality of a district or have a density of one trap/township (36 sq. mi.). Correct placement of the NJLT is a critical factor in its performance as an effective surveillance mechanism for measuring the relative abundance of phototaxic mosquitoes. Place the traps at six-foot height. This can be done by using a metal standard, or by hanging the traps from tree limbs or roof eaves. These distances should maximize attractancy over a 360 degree radius. The trap should be placed on the leeward side of a structure or tree line to decrease the influence of wind on trap catch.

Traps should be kept away from smoke or chemical odors that may be repellent to the mosquitoes. Traps should be away from buildings in which animals are housed and not be in the immediate vicinity of sentinel flocks to diminish attractancy competition. Traps should be placed away from street and security lights that may diminish attractancy of the trap bulb. A trap should be placed approximately 100-200 feet from each sentinel chicken flock when possible to link abundance with seroconversions.

Traps should be operated from week 14 to week 44 of the calendar year for districts north of the Tehachapi Mountains and all year long for districts south of the Tehachapi. Ideally, the traps should run for four to seven nights before the collection is retrieved (Loomis and Hanks 1959). The trap should be thoroughly cleaned with a brush to remove spider webs or any other debris that may hinder airflow through the trap. A regular cleaning schedule should be maintained during the trapping season to maintain trap efficiency.

Processing

Adult mosquitoes from the NJLT collection should be sorted from the other insects in an enamel pan before being identified and counted at 10x magnification under a dissecting microscope. Counting aliquots or subsamples of all specimen samples should be discouraged, because vector species may comprise only a small fraction of the total mosquito collection.

CDC style CO_2-baited trap

Operation

Carbon dioxide-baited traps can be used for abundance monitoring or capturing mosquitoes for virus testing. Traps should be hung from a 6-foot tall standard pole (approximately 4 feet above ground level) to standardize trap placement for population and virus infection rate monitoring. Knowledge of the host-seeking patterns of the target species is essential in

determining CO_2-baited trap placement in the habitat to enhance catch size and therefore sampling sensitivity. *Culex tarsalis* primarily bloodfeed on birds and hunt along vegetative borders and tree canopies where birds roost and nest. *Culex erythrothorax* are best collected within wetland areas near dense stands of tules and cattails. In large, open breeding sources such as rice fields, CO_2-baited traps could be hung on standards on the up-wind side of the source for *Culex tarsalis* and *Anopheles freeborni* collections. *Aedes melanimon* and *Aedes nigromaculis* are mammal feeders and typically seek hosts over open fields.

When used to supplement sentinel chickens for arbovirus surveillance, traps should be operated at different locations to enhance geographical coverage and thus surveillance sensitivity. Labor and time constraints determine the extent of sampling. When used to monitor population abundance, traps should be operated weekly or biweekly at the same fixed stations. Temperature, wind speed, wind direction, and rainfall should be recorded because these factors affect catch size. The mini-light may be removed, because it attracts other phototactic insects that may hinder sorting and/or damage female mosquitoes in the collection container and may repel members of the *Culex pipiens* complex. The CO_2-baited trap should not be placed in immediate proximity to the sentinel chicken flock because it will compete with, and therefore lessen, exposure of the sentinel birds, but may be placed within a 100-200 foot radius of the sentinel flock site, but no closer than 100 feet from the flock.

Processing

Mosquitoes collected for arbovirus surveillance should be processed according to the procedures outlined in Appendix B. If possible, ten pools of a species (*Culex tarsalis*, *Culex pipiens*, *Culex quinquefasciatus*, *Culex stigmatosoma*, *Aedes melanimon*, and *Aedes dorsalis*) should be submitted for virus testing from a given geographical location at a given time. Only live mosquitoes should be pooled for virus testing. Dead, dried specimens should be counted and discarded. Only whole specimens should be submitted; avoid including detached body parts (which may be from other mosquito species) or other Diptera (i.e., *Culicoides*, etc.) in the pool to prevent sample contamination. Avoid freezing specimens before sorting and counting. Mosquitoes collected for population monitoring should be anesthetized in a well-ventilated area or under a chemical hood using triethylamine, identified to species under a dissecting microscope, counted, pooled and immediately frozen at -80C or on dry ice for later virus testing.

Reiter/Cummings gravid traps

Trap design and components

The Reiter/Cummings gravid traps consist of a rectangular trap housing (plastic tool box) with an inlet tube on the bottom and an outlet tube on the side or top. The rectangular housing is provided with legs to stabilize the trap over the attractant basin containing the hay-infusion mixture. (Cummings 1992). The oviposition attractant consists of a fermented infusion made by mixing hay, Brewer's yeast and water. The mixture should sit at ambient temperature for a minimum of three to four days prior to use to allow fermentation and increase attractancy. New solutions should be made at least biweekly to maintain consistent attractancy.

Operation

The Reiter/Cummings gravid trap is primarily used in suburban and urban residential settings for surveillance of gravid females in the *Culex pipiens* complex. The trap is placed on

the ground near dense vegetation that serves as resting sites for gravid females. Specimens may be retrieved on a one to three day basis.

Processing

Culex pipiens complex females collected with the gravid trap for arbovirus surveillance should be retrieved daily and the protocol for mosquito pool submission as outlined in Appendix B should be followed. For population monitoring of the *Culex pipiens* complex, collections may be retrieved every third day. The females are killed, identified and counted before being discarded. Autogenous females may also be attracted to the gravid trap.

Adult resting collections

Trap design and operation

A flashlight and mechanical aspirator can be used to collect adult mosquitoes resting in habitats such as shady alcoves, buildings, culverts, or spaces under bridges. Highest numbers usually are collected at humid sites protected from strong air currents. Adults resting in vegetation may be collected using a mechanical sweeper such as the AFS (Arbovirus Field Station) sweeper (Meyer et al. 1983). For quantification, time spent searching is recorded and abundance expressed as the number collected per person-hour.

Red boxes were developed to standardize collections spatially. Different researchers have used red boxes of varying dimensions. Largest catches are made in semi-permanent walk-in red boxes which measure 4' x 4' x 6' (Meyer 1985). Smaller 1' x 1' x 1' foot boxes typically collect fewer specimens, but are readily portable. The entrance of the walk-in red box should be left open, draped with canvas, or closed with a plywood door. The canvas or plywood door should have a 1 or 2 ft gap at the bottom to allow entry of mosquitoes, while affording some protection from the wind and decreasing the light intensity within the box. The box entrance should not face eastward into the morning sun or into the predominant wind direction.

Processing

Mosquitoes should be anesthetized with triethylamine, identified under a dissecting microscope, sorted by sex and female metabolic status (i.e., empty or unfed, blood fed or gravid), and counted. Females may be counted into ten pools of approximately 50 females per site per collection date for virus monitoring (see Appendix B). Only living females should be used for arbovirus surveillance. Data on metabolic status may indicate population reproductive age as well as diapause status.

Data recording and analysis

Counts from NJLTs, EVS, and gravid traps and information on pools submitted for testing or tested locally should be entered directly in electronic format through the California Vectorborne Disease Surveillance Gateway (http://gateway.calsurv.org). Import from local or proprietary data systems is available. For comparisons of abundance over time, space, or collection methods, refer to Bidlingmayer (1969).

Data usage

Mosquito collections from some or all of the four sampling methods collectively can be used to:

1. Assess control efforts.
2. Monitor arbovirus vector abundance and infection rates.
3. Compare mosquito abundance from collections with the number of service requests from the public to determine the tolerance of neighborhoods to mosquito abundance.
4. Determine proximity of breeding source(s) by the number of males present in collections from the NJLTs and red boxes.
5. Determine age structure of females collected by CO_2 traps and resting adult collections; such data are critical to evaluating the vector potential of the population.

Appendix B: Procedures for Processing Mosquitoes for Arbovirus Detection

1. Collect mosquitoes alive and return them immediately to the laboratory. Collections should be kept humid during transport with moist toweling to prevent desiccation. Females should be offered 5-10 percent sucrose if held overnight or longer before processing.

2. Anesthetize mosquitoes by cold, carbon dioxide, or triethylamine (TEA). TEA is recommended because specimens are permanently immobilized with minimal mortality and with no loss of virus titer (Kramer et al. 1990). TEA should be used either outdoors or under a chemical hood. Collections can be anesthetized outdoors using a few drops of TEA, the specimens transferred to Petri dishes, and then taken into the laboratory for processing. If refrigerated and kept humid, mosquitoes will remain alive in covered Petri dishes for one or two days without additional anesthesia. If mosquitoes are frozen before processing, sorting to species and enumeration must be done on a chill table to prevent virus loss.

3. Sort mosquito collections to species under a dissecting microscope at 10X to ensure correct identification and to make sure that extraneous mosquito parts (i.e., legs, wings) or other small insects such as chironomids or *Culicoides* are not inadvertently included in the pools. This is extremely important because diagnostics have transitioned from virus isolation to sensitive RT-PCR methods of viral detection. Count and discard dead and dried mosquitoes. 50 females of each vector species per pool from each collection site are then counted into individual polystyrene vials with snap caps containing two 5mm glass beads. Recommended sampling effort is ten pools of 50 females of each species from each site per week to detect minimum infection rates (MIRs) ranging from 0 to 20 per 1,000 females tested. Vials with pools should be labeled sequentially starting with #1 each year after the site code; e.g., KERN-1-13; where 13 refers to year 2013. Data on each pool can be entered directly in electronic format through the California Vectorborne Disease Surveillance Gateway (http://gateway.calsurv.org/). POOLS MUST BE ACCOMPANIED BY "MOSQUITO POOLS SUBMITTED FORM MBVS-3" AND CAN ONLY BE TESTED FROM REGISTERED SITES. Surveillance sites should be registered online at: http://gateway.calsurv.org/**.** Faxed registration forms (MBVS-1) will be accepted from agencies without adequate internet access.

   List the site code for each pool that consists of a designated four-letter agency code followed by six digits identifying the site, i.e., KERN000001. Keep the pool numbers in sequence for the whole year regardless of the number of site codes: e.g., pool #1 may be from KERN000001, and pool #2 may be from KERN000004.

4. Freeze pools immediately at -70°C either on dry ice in an insulated container or in an ultra-low temperature freezer. Pools should be shipped frozen on dry ice to CVEC for testing by real time multiplex RT-PCR. Pools received by noon on Wednesday will be tested and reported by Friday or sooner. Agencies will receive an automated email notification that results have been entered into the CalSurv Gateway as well as a summary of positive pools; additionally, positive pools will be reported weekly in the California Arbovirus Surveillance Bulletin. Each pool is screened for WNV, SLE, and WEE viruses by a multiplex qRT-PCR assay, with positives with Ct scores >30 confirmed by a singleplex RT-PCR. Pools from

selected areas also are screened for additional viruses using Vero cell culture with isolates identified following sequencing. Care must be taken not to allow pools to defrost during storage or shipment, because each freeze-thaw cycle may result in a 10-fold decrease in viral titer, and all virus will be lost if the specimens sit at room temperature for extended periods. Address shipment to: Ying Fang, Center for Vectorborne Diseases, VetMed 3A room 3336, University of California at Davis, Davis CA 95616.

5. Local agencies that conduct their own testing by RT-PCR or RAMP® tests need to complete and pass a proficiency panel each year for the results to be reported by CDPH.

Appendix C: Procedures for Maintaining and Bleeding Sentinel Chickens

1. Procure hens in March or when they become available as notified by MVCAC when the chickens are 14-18 weeks of age to ensure minimal mortality during handling. Hens at this age have not yet begun to lay eggs, but they should have received all their vaccinations and been dewormed.
2. Recommended housing for chickens. Ten sentinel chickens can be housed in a 3Wx6Lx3H ft coop framed with 2x2 and 2x4 inch construction lumber and screened with no smaller than 1x1 inch welded wire. It is critical that the wire mesh be large enough to allow the mosquitoes to easily enter the coop and the coops be placed in locations with a history of arbovirus transmission and/or high mosquito abundance. The site of and band numbers located at each coop must be registered online at: http://gateway.calsurv.org/. Faxed registration forms (MBVS-1) will be accepted from agencies without adequate internet access. Coops should be at least two feet off the ground to reduce predator access, facilitate capture of the birds for bleeding, and allow the free passage of the feces through the wire floor to the ground. A single, hinged door should be placed in the middle of the coop, so that the entire coop is accessible during chicken capture. After construction, the lumber and roof should be protected with water seal. A self-filling watering device should be fitted to one end of the coop and a 25 lb. feeder suspended in the center for easy access. In exchange for the eggs, a local person (usually the home owner, farm manager, etc.) should check the birds (especially the watering device) and remove the eggs daily. If hung so the bottom is about four inches above the cage floor and adjusted properly, the feeder should only have to be refilled weekly (i.e., 100 lb. of feed per month per flock of ten birds). Therefore, if proper arrangements can be made and an empty 55-gallon drum provided to store extra feed, sentinel flocks need only be visited biweekly when blood samples are collected.
3. Band each bird in the web of the wing using metal hog ear tags and appropriate pliers. This band number, the date, and site registration number must accompany each blood sample sent to the laboratory for testing.
4. Bleed each hen from the distal portion of the comb using a standard lancet used for human finger "prick" blood samples. The bird can be immobilized by wedging the wings between the bleeder's forearm and thigh, thereby leaving the hand free to hold the head by grabbing the base of the comb with the thumb and forefinger. Use alcohol swabs on comb before bleeding. Blood samples are collected on half-inch wide filter paper strips, which should be labeled with the date bled and wing band number. The comb should be "pricked" with the lancet and blood allowed to flow from the "wound" to form a drop. Collect the blood by touching the opposite end of the pre-labeled filter paper strip to the wound. THE BLOOD MUST COMPLETELY SOAK THROUGH ON A ¾ INCH LONG PORTION OF THE STRIP. Place the labeled end of the strip into the slot of the holder (or "jaws" of the clothes pin) leaving the blood soaked end exposed to air dry.
5. Attach the completely dry filter paper strips to a 5x7 card in sequential order, from left to right by stapling the labeled end towards the top edge of the card, and leaving the blood soaked end free so that the laboratory staff can readily remove a standard punch sample. Write the County, Agency Code, Site, and Date Bled onto the card and place it into a zip lock plastic bag. Do not put more than one sample card per bag. It is important that blooded ends do not become dirty, wet, or touch each other. VERY IMPORTANT:

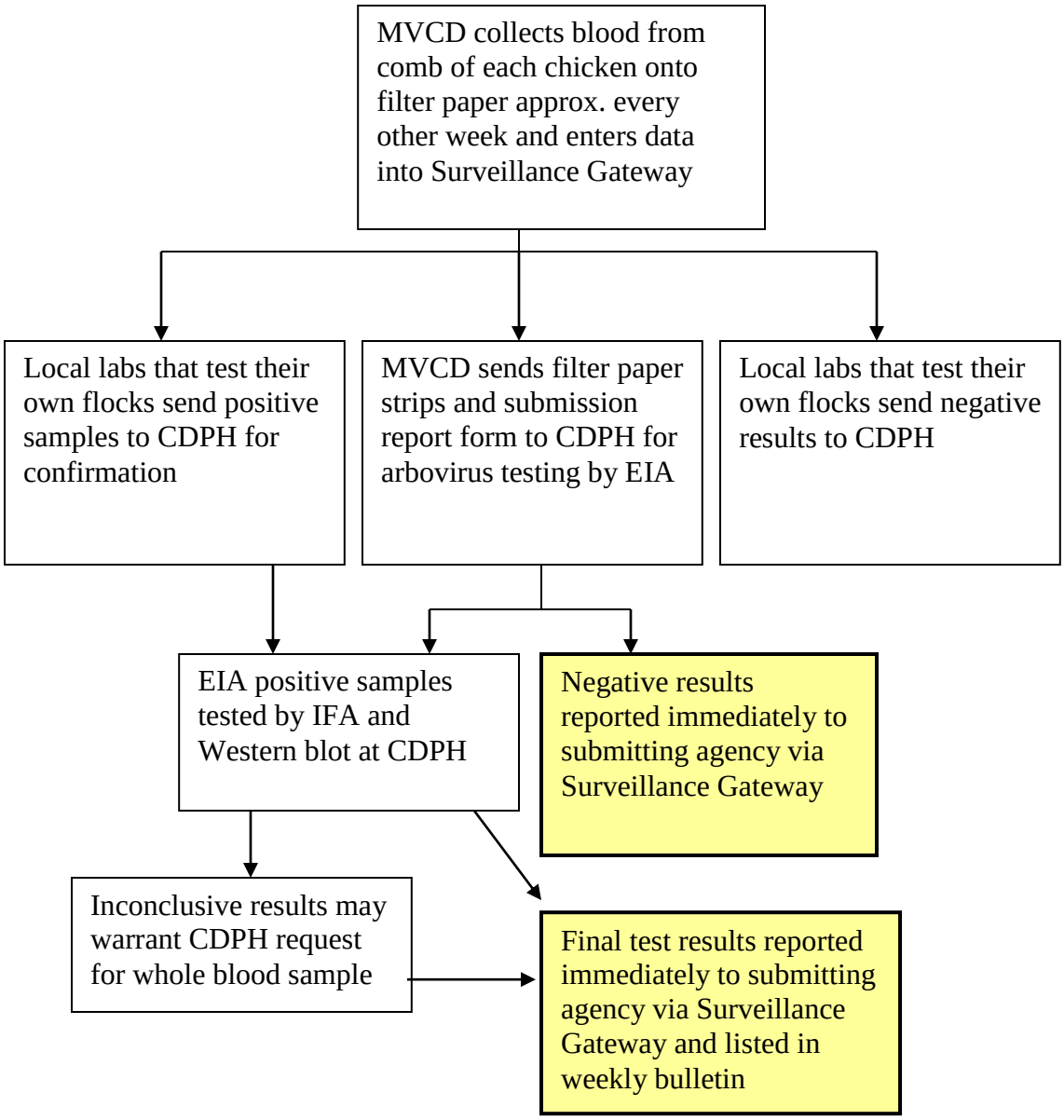
CHICKEN SERA MUST BE ACCOMPANIED BY SENTINEL CHICKEN BLOOD FORM (MBVS- 2) OUTSIDE THE ZIP-LOCK BAG. Do not staple the form to the bag. Samples from each bleeding date then can be placed into a mailing envelope and sent to:

Department of Public Health, Richmond Campus
Specimen Receiving Unit Room B106 **(ATTN: ARBO)**
850 Marina Bay Parkway
Richmond, CA 94804

Specimens will be tested within 1-3 days upon receipt by the laboratory.

6. In the laboratory, a single punch is removed from the blooded end of the paper and tested for WEE, SLE, and WNV IgG antibodies using ELISA (Patiris et al. 2008; Taketa-Graham et al. 2010). Positive specimens are tested further with an indirect fluorescent antibody test and confirmed with a Western blot. Inconclusive SLE or WNV positives are confirmed and identified by cross-neutralization tests. Agencies will receive an automated email notification that results have been entered into the CalSurv Gateway; additionally, positive chickens will be reported in the weekly California Arbovirus Surveillance Bulletin.

California Procedure for Testing Sentinel Chickens for the Presence of Antibodies to Flaviviruses (SLE and WNV) and WEE



Key:

EIA:	Enzyme immunoassay test
IFA:	Indirect fluorescent antibody test
MVCD:	Local Mosquito and Vector Control District/Health Dept.
SLE:	St. Louis encephalitis
CDPH:	CDPH Vector-Borne Disease Section, Richmond
WEE:	Western equine encephalitis
WNV:	West Nile virus encephalitis

Surveillance for Mosquito-borne Viruses
Registration of Agencies and Sites

1. Participation of agencies

Agencies interested in participating in the statewide surveillance program for mosquito-borne viruses should place orders for mosquito pool testing by UC Davis Center for Vectorborne Diseases (CVEC) through the Mosquito and Vector Control Association (MVCAC). Sentinel chicken testing should be ordered through the California Department of Public Health (CDPH). Agencies will be billed in advance for the number of samples to be tested.

Agencies are responsible for registering and maintaining updated information for their sites online at: http://gateway.calsurv.org/.

2. Registration of sentinel flock sites and wing band numbers

Agencies must use the unique band numbers assigned to their district by CDPH each year. Prior to submitting any sentinel chicken blood samples to CDPH, each agency must ensure that each flock site and accompanying band numbers are registered online at: http://gateway.calsurv.org. CDPH will only test samples if they are accompanied by the form "SENTINEL CHICKEN BLOOD – 2013" (MBVS-2) for each flock site, which includes the registered agency code, the registered site code (assigned by local agency), the wing band numbers assigned to that site, and date bled. **Also, the form should indicate any changes made and match the sample card exactly.**

3. Registration of mosquito sampling sites

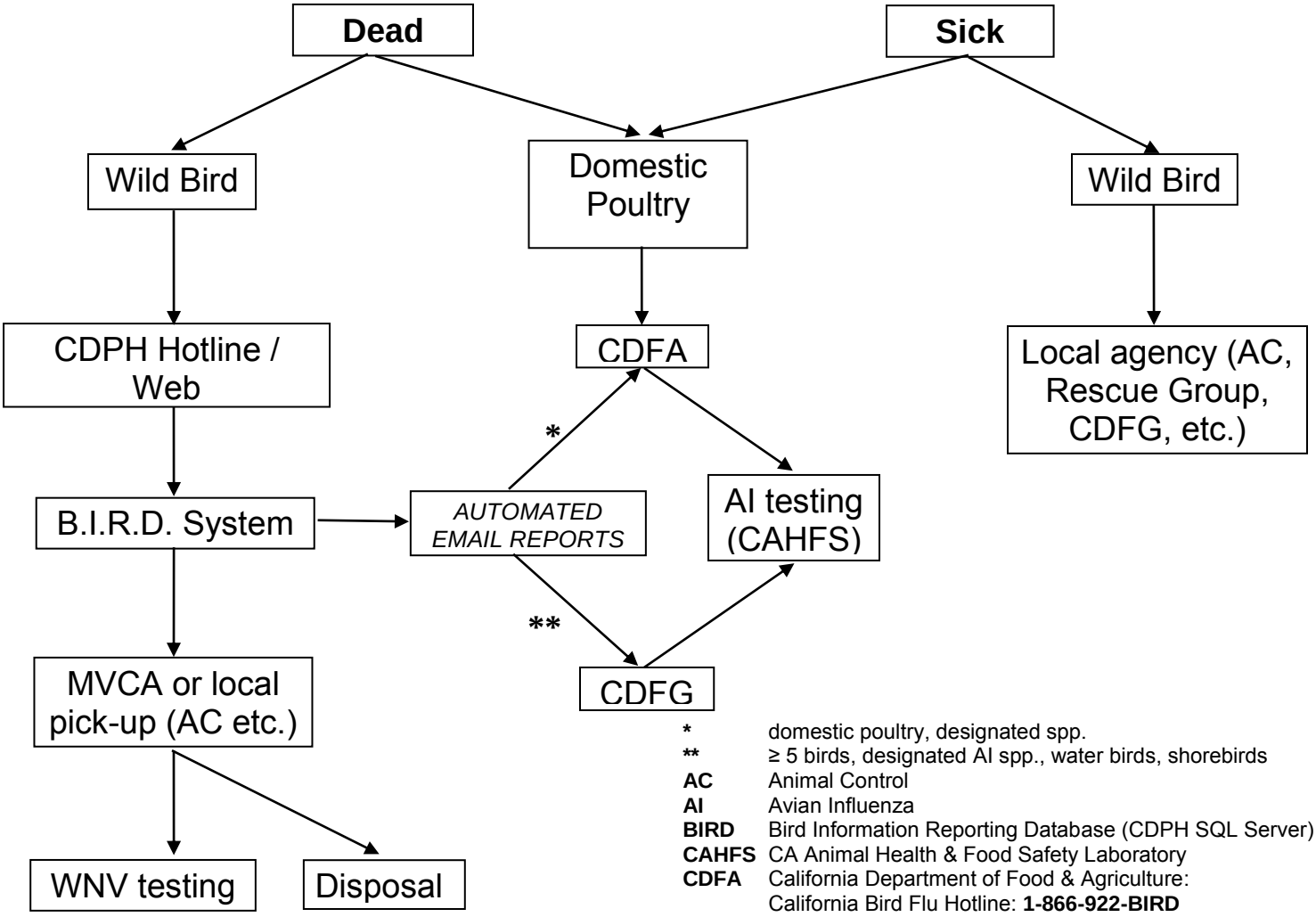
Registration of new sites used for collection of mosquitoes for virus testing may be accomplished by accessing the California Vectorborne Disease Surveillance Gateway http://gateway.calsurv.org/. Since 2010, the CalSurv Gateway has included enhanced spatial capabilities that allow users the option of directly entering geographic coordinates for sites or interactively selecting the location using a new Google Maps-based interface. The laboratory will test the pools provided that adequate information is provided on the "MOSQUITO POOL SUBMISSION" form (MBVS-3, revised 01/12/06), including your agency code, your site code for the site and geographic coordinates.

The geographic coordinates will be used to generate computer maps that show all registered sites and test results for each site. Also, as part of a collaborative effort, CVEC will host real-time maps in ArcGIS format at http://maps.calsurv.org. In addition to these maps, agencies can access maps using Google Earth through the California Vectorborne Disease Surveillance Gateway (http://gateway.calsurv.org) that provide enhanced functionality and detail.

Appendix D: Procedures for Testing Dead Birds and Squirrels

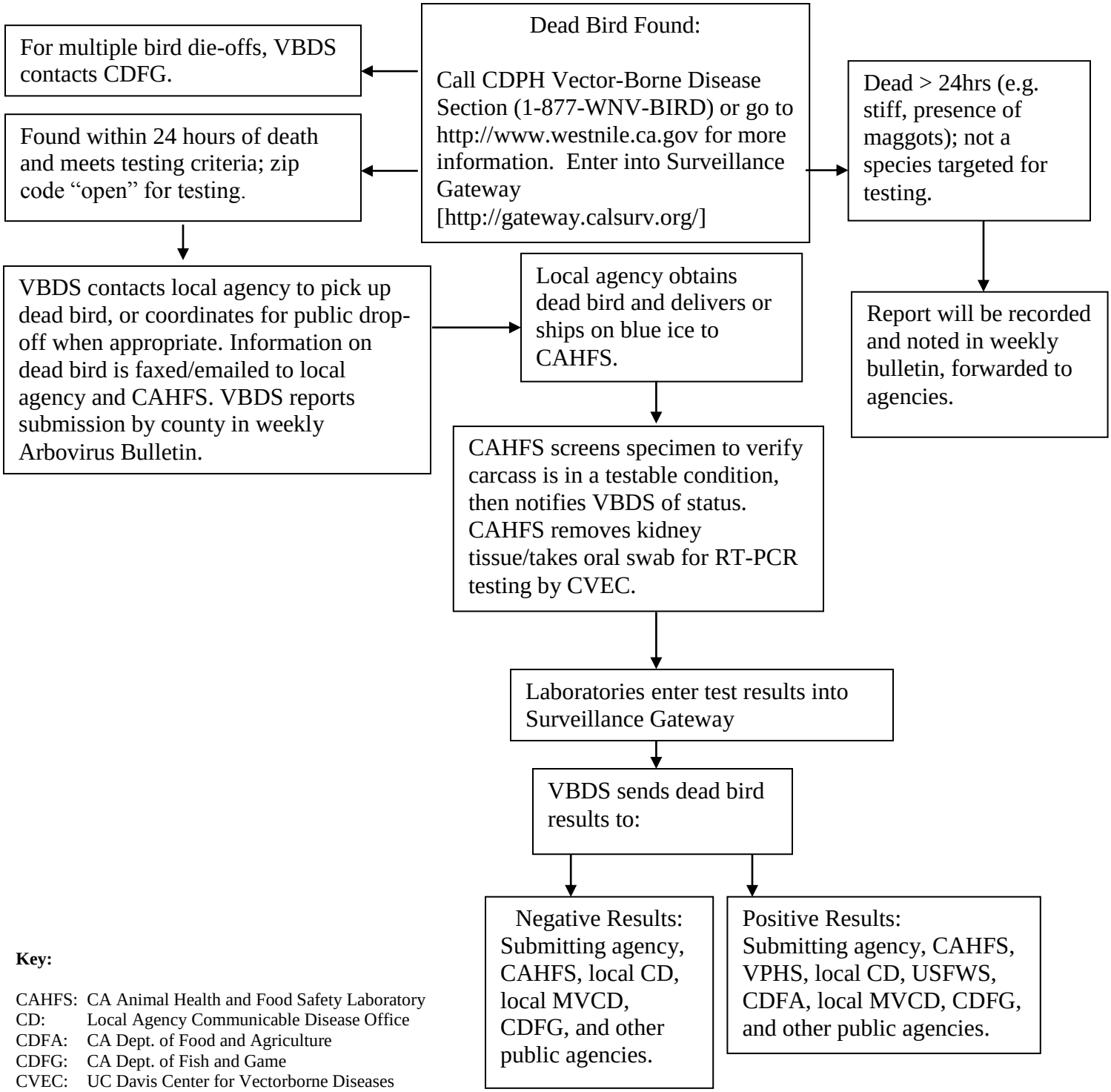
In 2000, CDHS initiated a dead bird surveillance program in collaboration with other public agencies. CDPH annually notifies about 600 agencies, organizations, and veterinarians involved with wildlife, including rehabilitation centers, about the program. The public is also notified about the program through the media and outreach materials. Dead birds and squirrels are reported to CDPH or data entered electronically through the Surveillance Gateway [http://gateway.calsurv.org/] and shipped to the California Animal Health & Food Safety (CAHFS) laboratory at UC Davis for screening and removal of kidney tissue (an oral swab is taken instead if the bird is an American Crow), which is then sent to the UC Davis Center for Vectorborne Diseases (CVEC) for WNV RNA detection via RT-PCR. Beginning in 2010, results from RT-PCR testing at CVEC distinguished between WNV recent and chronic positive birds based on cycle threshold (Ct) values. Chronic positive birds did not likely die from WNV infection and are of limited value for surveillance. Overviews of the dead bird reporting and testing algorithms are provided below.

Sick / Dead Bird Reporting Protocol for Public and Local Agencies



*	domestic poultry, designated spp.
**	≥ 5 birds, designated AI spp., water birds, shorebirds
AC	Animal Control
AI	Avian Influenza
BIRD	Bird Information Reporting Database (CDPH SQL Server)
CAHFS	CA Animal Health & Food Safety Laboratory
CDFA	California Department of Food & Agriculture: California Bird Flu Hotline: **1-866-922-BIRD**
CDFG	California Department of Fish & Game http://www.dfg.ca.gov/regions/index.html
CDPH	California Department of Public Health West Nile virus & Dead Bird hotline: **1-877-968-BIRD** website: www.westnile.ca.gov
MVCA	Mosquito & Vector Control Agency

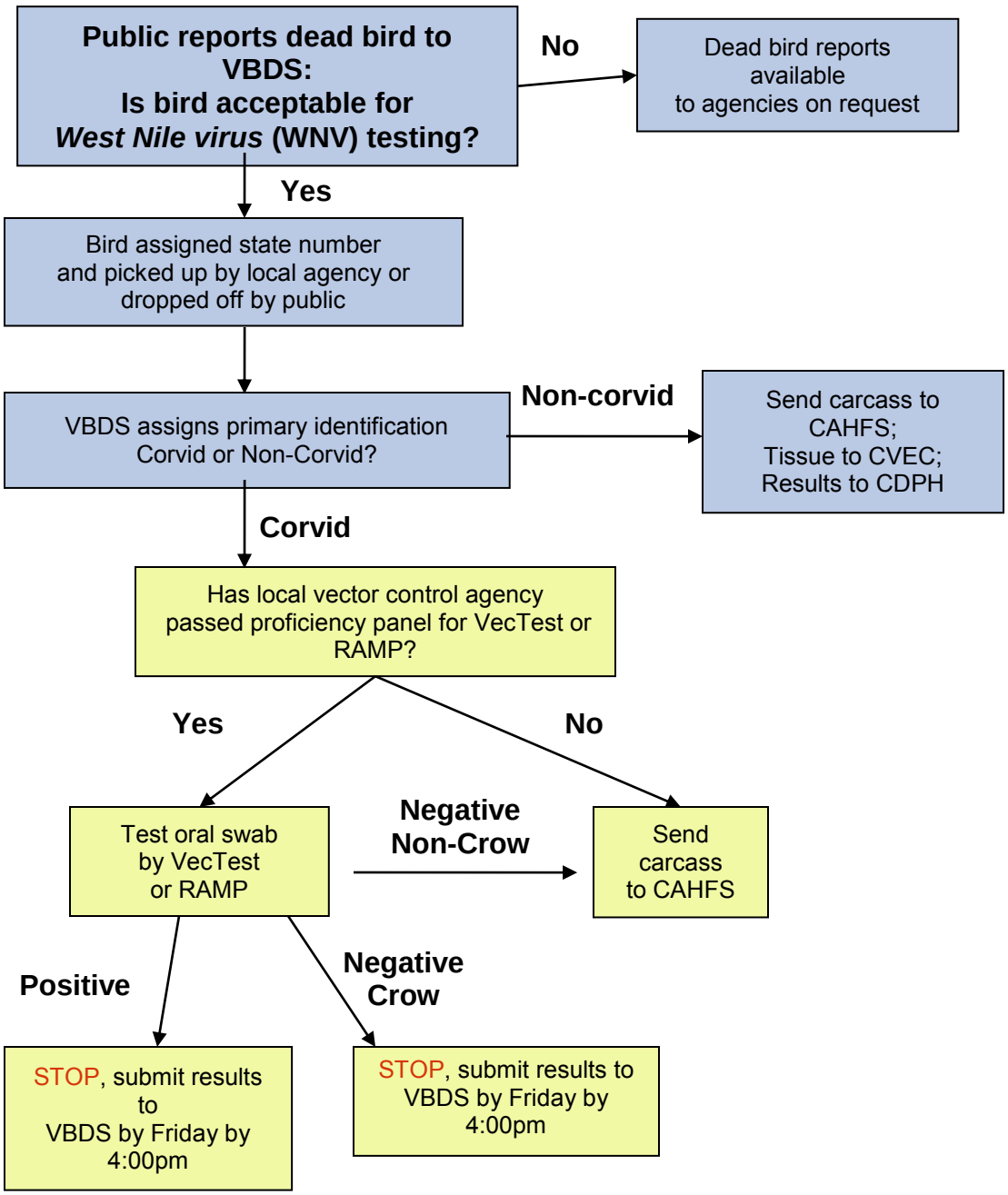
Procedures for Testing Dead Birds: RT-PCR



Key:

CAHFS: CA Animal Health and Food Safety Laboratory
CD: Local Agency Communicable Disease Office
CDFA: CA Dept. of Food and Agriculture
CDFG: CA Dept. of Fish and Game
CVEC: UC Davis Center for Vectorborne Diseases
MVCD: Local Mosquito and Vector Control District
USFWS: US Fish and Wildlife Service
VBDS: CDHS Vector-Borne Disease Section, Richmond
VPHS: CDHS Veterinary Public Health Section, Sacramento
IHC: Immunohistochemistry

Procedures for Testing Dead Birds: Rapid Assays



CVEC = Center for Vectorborne Disease Research, UC Davis
VBDS = Vector-Borne Disease Section, California Department of Public Health
CAHFS = California Animal Health and Food Safety Laboratory

VBDS

Local Agencies

Dead Bird and Tree Squirrel Reporting and Submission Instructions for Local Agencies
California West Nile Virus (WNV) Dead Bird & Tree Squirrel Surveillance Program
California Department of Public Health (CDPH)
Division of Communicable Disease Control

When your agency receives a call from the public about a dead bird (especially recently dead crows, ravens, magpies, jays, or raptors) or dead tree squirrel, or one of your staff finds any dead bird, please immediately refer them to the **CDPH West Nile Virus and Dead Bird Hotline at 1-877-WNV-BIRD (968-2473)**.

The Dead Bird Hotline is monitored **8am - 5pm, Monday-Friday (7 days a week May-October).** Reports can also be made after hours via voicemail prompts and on the WNV website: www.westnile.ca.gov**.** CDPH will assess the suitability of the dead bird or tree squirrel for testing and contact your agency if the carcass is approved for pickup. Any carcasses sent without prior notification will not be tested.

Agencies may call **the agency phone number, 510-412-4601**, to coordinate bird pick-ups with hotline operators. If your agency collects a dead bird for testing and it is in suitable condition, you can call this number to receive a dead bird number and submission form prior to shipping.

Only agencies listed under the permit issued to CDPH from the California Department of Fish & Wildlife are authorized to pick up dead birds and tree squirrels. The agencies covered include local mosquito abatement districts, environmental health departments, and other designated agencies.

Members of the public may salvage dead birds found on their property or place of residence if the local agency has indicated to CDPH they will accept public salvage. **The public must first call the Dead Bird Hotline and obtain a Dead Bird Number**; a corresponding public salvage submission form will then be faxed to the appropriate agency. The public will be instructed by the hotline staff to double-bag the carcasses and drop them off at the designated agency within 24 hours, between 9 am - 3 pm, Monday – Friday. **Note: only dead birds may be brought in by the public to local agencies for shipping. We discourage public salvage of all squirrels because ground squirrels, which could be infected with plague, may be misidentified as tree squirrels.**

***web links*:** bird and tree squirrel ID chart (pdf) tree squirrel surveillance Q&A (pdf)

Once the submission is approved, your agency can ship the carcass to the California Animal Health & Food Safety laboratory at UC Davis (CAHFS Central). CAHFS Central removes specific tissues and forwards the samples to the UC Davis Center for Vectorborne Diseases (CVEC) for WNV testing. Shipping and testing expenses will be paid by CDPH. Carcasses are considered **Category B, Biological Substances.** This replaces the old designation, "Diagnostic Specimen".

To ensure the carcass arrives at CAHFS in a testable condition, to protect your safety, and to comply with shipping regulations, please follow these instructions:

- Only dead birds and tree squirrels can be picked up under our permit.

- Wear rubber or latex gloves when handling all carcasses. If gloves are not available, use a plastic bag -- turned inside out -- over your hand and invert the bag to surround the carcass. Do not touch a carcass with bare hands.

- **Collect fresh carcasses.** Badly decomposed or scavenged carcasses are of limited diagnostic value. Signs that a bird or squirrel has been dead for too long (over 24-48 hours) are the presence of maggots, an extremely lightweight carcass, missing eyes, skin discoloration, skin or feathers that rub off easily, strong odor, or a soft, mushy carcass.

- **If upon pick-up the carcass is found to be unacceptable (e.g. a species your agency or CDPH is not accepting or a badly decomposed specimen), please collect the carcass, double-bag it, and dispose of it in a secure garbage can or dumpster.** California Department of Fish & Game prefers that you burn or bury the carcass, but disposing of it in a dumpster is also acceptable. **Please call CDPH immediately and notify us that the animal will no longer be submitted.**

- Place each carcass into a sealed (zip-locked) plastic bag. **This prevents cross-contamination and leakage**. **There should always be a bag separating the carcass from shipping documents.**

- Enclose the shipping documents and the carcass (sealed in a zip-locked bag) into a second zip-locked bag. The primary shipping document is a copy of the dead bird submission form which contains the dead bird number and which is located on the Surveillance Gateway [http://gateway.calsurv.org/] or faxed by CDPH. CAHFS prefers that you put this inside the outer bag containing the dead bird or squirrel.

- Pack the carcass with blue ice packs. **Please limit the number of ice packs** to the number required to keep the carcass fresh, as the weight of extra ice packs add to the shipping charges. In accordance to shipping regulations, an absorbent material such as newspaper must be included in the box to prevent any leakage.

- Ship the carcass in a hard-sided plastic cooler or a Styrofoam cooler placed in a cardboard box. Unprotected Styrofoam containers cannot be shipped without an outer box or container, as they may break into pieces during shipment. **Contact GSO directly to arrange for carrier pickup Monday through Thursday; this guarantees arrival at CAHFS before the weekend.**

- Contact **GSO** to pick up carcasses at **1-800-322-5555**. Our shipping account is **22971** and our zip code is **94804**.

- Carcasses that need to be stored for an extended time period (over 2 days) should be put on dry ice or stored at -70ºC. If it is not possible to store carcass at -70ºC, a carcass may be stored at 0ºC (regular freezer) for a short period of time. **Refrigerating** the carcass is recommended for **overnight storage only** (this slows virus deterioration, but does not stop it).

- CDPH will provide prepared shipping boxes with appropriate labels. Any empty boxes shipped to your agency from CDPH will have its caution labels covered by a sheet of paper with "EMPTY BOX" printed on it. Please discard this sheet of paper before using the box to ship out a dead bird. If you need additional boxes, please contact VBDS at (510) 412-6251 or email arbovirus@cdph.ca.gov.

- Once agencies pass the yearly proficiency panel, agencies may conduct in-house testing. Results can be entered directly into the Surveillance Gateway. Please **enter results by 4:00pm Tuesday of each week to have results included in reports for that week's State WNV updates. Note: any positive bird must be disposed of as biomedical waste (incineration).**

Dead Bird Shipping List

Please verify that your agency has the following items:

- CAHFS Address (see below)
- GSO preprinted labels
- Agency-only number for hotline (510-412-4601)
- WNV hotline number, 1-877-WNV-BIRD (968-2473); staffed 8am - 5pm, 7 days a week during summer
- Crumpled newspapers or another absorbent material
- Rubber or Latex Gloves
- Packing tape
- Dead Bird Shipping Boxes
  - inner zip-lock bag
  - outer zip-lock bag
  - inner styrofoam box
  - outer cardboard box
  - blue ice packs

California Animal Health & Food Safety (CAHFS) laboratory:

CAHFS Central (530) 754-7372
ATTN: WNV
Jacquelyn Parker
University of California, Davis
West Health Science Drive
Davis, CA 95616

Appendix E: Procedures for Testing Equines and Ratites

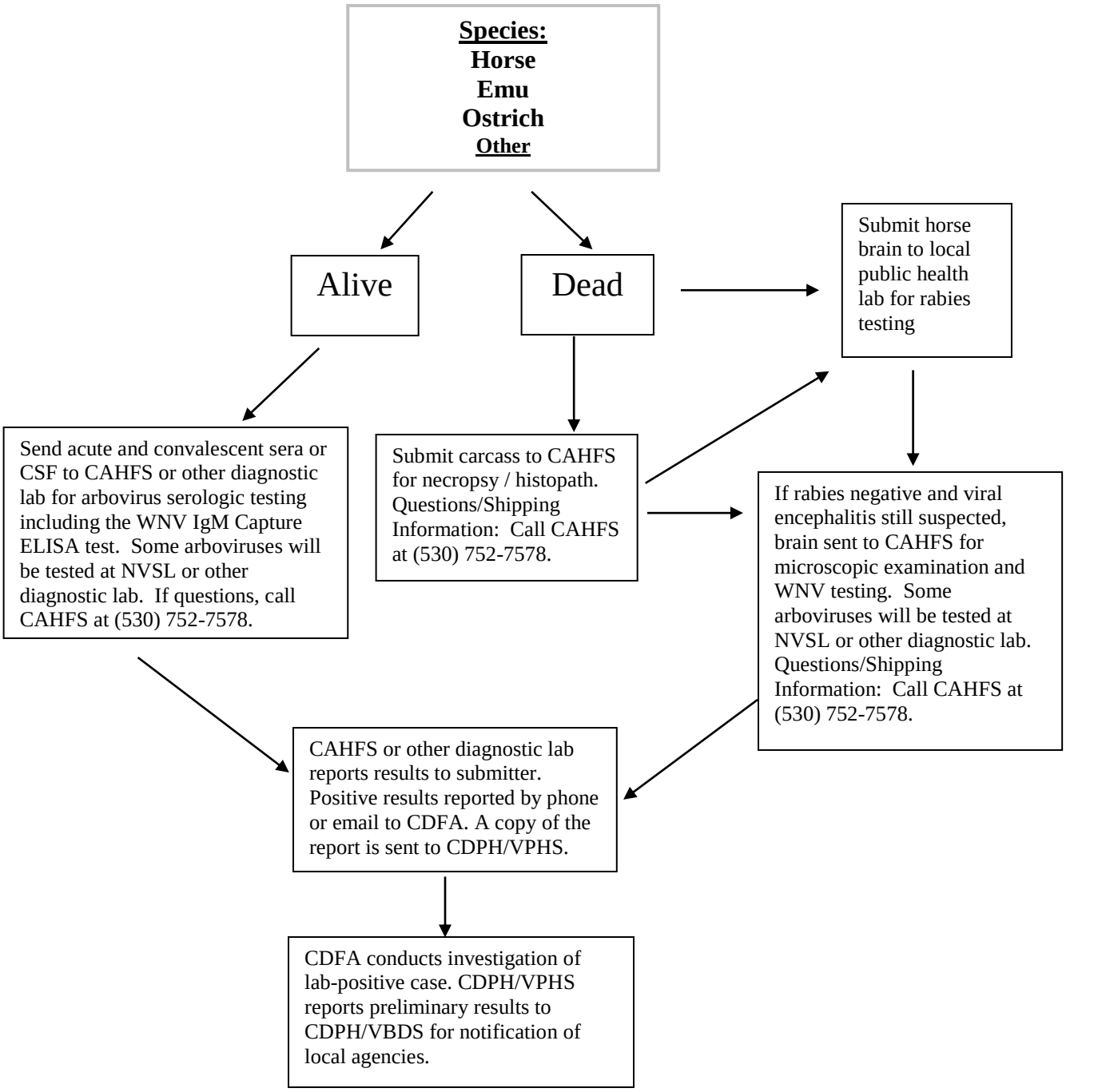
The California Departments of Public Health (CDPH) and Food and Agriculture (CDFA) developed a cooperative passive surveillance program for equine and ratite encephalomyelitis. Primary responsibility for equine and ratite West Nile virus (WNV) surveillance rests with CDFA. Equine encephalomyelitides are legally reportable to CDFA by veterinarians and diagnostic laboratories pursuant to Section 9101 of the Food and Agricultural Code. Venezuelan equine encephalomyelitis is an emergency animal disease that must be reported to CDFA by telephone within 24 hours.

This appendix contains information sent to veterinarians, public health lab directors, local health officers, public health veterinarians, animal health branch personnel, and interested parties every spring to inform them about the California Equine and Ratite Arbovirus Surveillance Program. The mailing includes a case definition for equine encephalomyelitides and instructions for specimen collection and submission for both equine and ratite samples. The information is distributed to approximately 1,200 practitioners, equine organizations, and other interested parties. Specimen submission is coordinated through the California Animal Health and Food Safety Laboratory System (CAHFS) and other laboratories or individual veterinarians. Equine serum and cerebrospinal fluid are tested by CAHFS using the ELISA test to detect anti-WNV IgM. Equine neurologic tissue specimens are also sent to CAHFS for microscopic examination and, as indicated by clinical findings, forwarded to the USDA National Veterinary Services Laboratories (NVSL) for further arbovirus testing. All fatal cases of equine encephalitis are first evaluated for rabies at the local public health laboratory. An algorithm outlining the protocol for specimen submission and reporting is available for participants in the program and is included in this appendix.

Outreach is an important component of the program. CDPH and CDFA have developed and distributed educational materials about the diagnosis and reporting of arboviruses in equines and ratites.

Additional information on WNV for veterinarians, horse owners, and ratite owners, is available from CDFA, Animal Health Branch (916) 900-5002, and at the CDFA website: http://www.cdfa.ca.gov/AHFSS/Animal_Health/WNV_Info.html. Information on submission of laboratory samples is available from CAHFS (530) 752-8700 and at CAHFS website: http://cahfs.ucdavis.edu. A brochure containing facts about California WNV surveillance and general information about prevention and control is available from CDPH (916) 552-9730 and at CDPH's website: http://www.westnile.ca.gov; a special section for veterinarians and horse owners is available at: http://www.westnile.ca.gov/resources.php.

Algorithm for Submission of Specimens from Domestic Animals with Neurologic Symptoms



Key:

AHB:	Animal Health Branch
CAHFS:	California Animal Health and Food Safety Laboratory
NVSL:	National Veterinary Services Laboratory
VBDS:	CDPH Vector-Borne Disease Section
VPHS:	CDPH Veterinary Public Health Section
CDFA:	California Department of Food and Agriculture
CDPH:	California Department of Public Health

SURVEILLANCE CASE DEFINITIONS FOR WEST NILE VIRUS DISEASE IN EQUINES

NOTE: A HORSE WITH SIGNS OF ENCEPHALITIS MAY HAVE RABIES – TAKE PROPER PRECAUTIONS

CONFIRMED CLINICAL CASE:

A horse with compatible clinical signs including ataxia (stumbling, staggering, wobbly gait, or in-coordination) or at least two of the following: fever, circling, hind limb weakness, inability to stand, multiple limb paralysis, muscle fasciculation, proprioceptive deficits, blindness, lip droop/paralysis, teeth grinding, acute death.

Plus one or more of the following:

- Isolation of West Nile (WNV) virus from tissues[1]
- Detection of IgM antibody to WNV by IgM-capture ELISA in serum or CSF
- A four-fold or greater change in plaque-reduction neutralization test (PRNT) antibody titer to WNV in appropriately timed[2], paired sera
- Positive polymerase chain reaction (PCR)[3] for WNV genomic sequences in tissues[1]
- Positive IHC for WNV antigen in tissue (Note: this test has low sensitivity in equids)

SUSPECT CLINICAL CASE[4]:

- Compatible clinical signs

EXPOSED EQUID:

- Detection of IgM antibody to WNV by IgM-capture ELISA in serum or CSF without any observable or noted clinical signs.

Assumptions on which case definition is based:

- Antibody in serum may be due to vaccination or a natural exposure; additional testing must be done to confirm WNV infection in a vaccinated horse.
- IgM antibody in equine serum is relatively short-lived; a positive IgM-capture ELISA means exposure to WNV or rarely a closely related flavivirus (SLE) has occurred, very likely within the last three months.

[1] Preferred diagnostic tissue are equine brain or spinal cord; although tissues may include blood or CSF, the only known reports of WNV isolation or positive PCR from equine blood or CSF have been from experimentally infected animals.
[2] The first serum should be drawn as soon as possible after onset of clinical signs and the second drawn at least seven days after the first.
[3] For horses it is recommended that RT-nested polymerase chain reaction assay be used to maximize sensitivity of the test (Emerg. Infect. Dis. 2001 Jul-Aug; 7(4):739-41)
[4] An equine case classified as a suspect case should, if possible, undergo further diagnostic testing to confirm or rule out WNV as the cause of the clinical illness.

Protocol for Submission of Laboratory Specimens for Equine Neurological Disease Diagnosis and Surveillance

Complete information on specimen collection and submission is available on the CDFA website at: http://www.cdfa.ca.gov/ahfss/Animal_Health/WNV_Lab_Submission.html

1. Specimen collection and submission:

A. Blood

- Acute sample (5-10 ml) / no later than 7 days after onset
- Convalescent sample (5-10 ml) / 14-21 days after onset
  Red top tubes of whole blood or serum (no preservatives or anticoagulants) should be submitted at ambient temperature to the California Animal Health and Food Safety (CAHFS) Laboratory* in your area. Do not freeze whole blood.
- **NOTE**: For WNV, an acute sample only is required since the assay used detects IgM (and vaccine does not interfere). For the other encephalitis viruses, the acute sample should be submitted immediately, and a convalescent sample may be requested later to assist with the interpretation and differentiation of vaccine titers from active infection.

B. Brain

- The local health department and CDFA/Animal Health District Office should be contacted if rabies is suspected.
- **The animal or intact head should be submitted to a CAHFS laboratory in your area as quickly as possible.** The intact head should be refrigerated, *not* frozen, immediately after removal using a leak-proof insulated transporting container with "cold packs" to keep the specimen at 4° C while in transit. *When it is impossible for the CAHFS Laboratory to receive the carcass or chilled intact head within 48 hours, the submission protocol should be coordinated with the CAHFS Laboratory.* Submission of the head intact is preferable to removal of the brain because: 1) the brain is better preserved (anatomically and virus titer) when left in the skull during transport, 2) specimens may be compromised if removal is not performed correctly, and 3) brain removal in field conditions may increase the risk of exposure to rabies.
- All equine specimens submitted first to the CAHFS Laboratory will be forwarded to: 1) a Public Health Laboratory to initially confirm or rule out rabies, then to 2) The National Veterinary Services Laboratories (NVSL) for arboviral testing, in addition to a complete diagnostic work-up at the CAHFS.
- All equine specimens submitted first to local public health laboratories for rabies testing and found to be negative should be forwarded to the local CAHFS Laboratory for arboviral testing.

C. Other specimens for differential neurological diagnoses

- Protocol for submission of these specimens may be coordinated through the CAHFS Laboratory, and may include sampling for equine herpes virus, EPM, or other agents associated with clinical neurological presentations.

2. Submission forms: Complete and include the transmittal forms supplied by the CAHFS Laboratory. See attached sample or download the form from their website: http://cahfs.ucdavis.edu/. The submission form for each specimen should be placed in a leak-proof plastic bag and attached to the corresponding container.

3. Imperative information to include on the submission forms if West Nile virus is suspected: Precision case reporting by the veterinary practitioner is critical to mosquito control efforts that prevent WNV infection in both horses and humans. It is very important that each laboratory submission form is completed in its entirety. More specifically, it is imperative to include and communicate to us:

- The locations(s) of the horse during the two weeks prior to the onset of clinical disease. (Please ensure that this information is included in the addition to the owner's address)
- Detailed clinical signs
- The present condition of the horse (include dead and euthanized)
- An accurate vaccination history

4. Shipment: For information on sample shipping including regulations governing the transportation of infectious materials contact CAHFS at 530-752-7578.

Appendix F: Protocol for Submission of Laboratory Specimens for Human West Nile Virus Testing

West Nile virus (WNV) testing within the regional public health laboratory network (i.e., the California Department of Public Health Viral and Rickettsial Disease Laboratory and participating local public health laboratories) is recommended for individuals with the following symptoms, particularly during West Nile virus "season," which typically occurs from July through October in California:

A. Encephalitis
B. Aseptic meningitis (Note: Consider enterovirus for individuals ≤ 18 years of age)
C. Acute flaccid paralysis; atypical Guillain-Barré Syndrome; transverse myelitis; or
D. Febrile illness*
   - Illness compatible with West Nile fever and lasting ≥ 7 days
   - Must be seen by a health care provider

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* The West Nile fever syndrome can be variable and often includes headache and fever (T ≥ 38°C). Other symptoms include rash, swollen lymph nodes, eye pain, nausea, or vomiting. After initial symptoms, the patient may experience several days of fatigue and lethargy.

Required specimens:

- Acute serum: ≥ 2cc serum

If a lumbar puncture is performed and residual CSF is available:

- Cerebral spinal fluid (CSF): 1-2cc CSF

If West Nile virus is highly suspected and acute serum is negative or inconclusive, request:

- 2nd serum: ≥ 2cc serum collected 3-5 days after acute serum

Contact your local health department for instructions on where to send specimens.

Appendix G: Surveillance Case Definition for West Nile Virus Infection in Humans

West Nile virus infection is reportable to local health departments under Title 17 of the California Code of Regulations. Blood donors that test positive for West Nile virus through blood bank screening should also be reported to CDPH, regardless of clinical presentation.

CASE DEFINITION: West Nile Virus

NOTE: This definition is for public health surveillance purposes only. It is not intended for use in clinical diagnosis.

Symptomatic Cases (adapted from 2011 CSTE case definition http://www.cdc.gov/osels/ph_surveillance/nndss/casedef/arboviral_current.htm)

Clinical criteria for diagnosis

Neuroinvasive disease

- Fever (≥100.4°F or 38°C) as reported by the patient or a health-care provider, **AND**
- Meningitis, encephalitis, acute flaccid paralysis, or other acute signs of central or peripheral neurologic dysfunction, as documented by a physician, **AND**
- Absence of a more likely clinical explanation.

Non-neuroinvasive disease

- Fever (≥100.4°F or 38°C) as reported by the patient or a health-care provider, **AND**
- Absence of neuroinvasive disease, **AND**
- Absence of a more likely clinical explanation.

Case classification

Confirmed = A case that meets the above clinical criteria and one or more of the following laboratory criteria for a confirmed case:

- Isolation of virus from, or demonstration of specific viral antigen or nucleic acid in, tissue, blood, CSF, or other body fluid, **OR**
- Four-fold or greater change in virus-specific quantitative antibody titers in paired sera, **OR**
- Virus-specific immunoglobulin M (IgM) antibodies in serum with confirmatory virus-specific neutralizing antibodies in the same or a later specimen, **OR**
- Virus-specific IgM antibodies in CSF and a negative result for other IgM antibodies in CSF for arboviruses endemic to the region where exposure occurred.

Probable = A case that meets the above clinical criteria and the following laboratory criteria:

- Virus-specific IgM antibodies in CSF or serum but with no other testing.*
  **CDPH recommends that virus-specific IgG antibody testing (e.g. EIA or IFA) also be performed. A specimen that is IgM-positive only (i.e. IgG-negative) may be a false*

positive, while a specimen that is both WNV IgM- and IgG-positive is more likely a true infection.

Presumptive Viremic Donors (Asymptomatic)

Asymptomatic infection with WNV, which is generally identified in blood donors, is also reportable. Blood donors who test positive for WNV may not necessarily be ill, nor will they initially have positive IgM or IgG antibody test results. Local health departments should report blood donors who meet the following criteria for being a presumptively viremic donor to CDPH-CDER:

A presumptively viremic donor (PVD) is a person with a blood donation that meets at least one of the following criteria:

a) One reactive nucleic acid-amplification (NAT) test with signal-to-cutoff (S/CO) ≥ 17
b) Two reactive NATs

Additional serological testing is not required. Local health departments should follow up with the donor after two weeks of the date of donation to assess if the patient subsequently became ill. If the donor did become ill as a result of WNV infection, the disease incident should be reclassified as "West Nile virus – Non-neuroinvasive" or "West Nile virus – Neuroinvasive," depending on the individual's clinical symptoms.

Appendix H: Compounds Approved for Mosquito Control in California

Label rates and usage vary from year to year and geographically; consult your County Agricultural Commissioner and the California Department of Fish and Game before application. Examples of products containing specific active ingredients are provided below, but this is not an inclusive list nor constitutes product endorsement. For more information on pesticides and mosquito control, please refer to the Environmental Protection Agency (EPA) Web site: http://www.epa.gov/opp00001/factsheets/westnile.htm

Larvicides:

1. *Bacillus thuringiensis* subspecies *israelensis* (Bti: e.g. Aquabac 200G, VectoBac® 12AS, Teknar HP-D)
   Use: Approved for most permanent and temporary bodies of water.
   Limitations: Only works on actively feeding stages. Does not persist well in the water column.

2. *Bacillus sphaericus* (Bs: e.g. VectoLex® CG)
   Use: Approved for most permanent and temporary bodies of water.
   Limitations: Only works on actively feeding stages. Does not work well on all species. May persist and have residual activity in some sites.

3. Spinosad (e.g. Natular™ G30)
   Limitations: Effective against all larval stages and moderately effective against pupal stage. Toxic via ingestion and contact. Some formulations approved for use in OMRI certified organic crops.

4. IGRs (Insect Growth Regulators)
   a. (S)-Methoprene (e.g. Altosid® Pellets)
   Use: Approved for most permanent and temporary bodies of water.
   Limitations: Works best on older instars. Some populations of mosquitoes may show some resistance.
   b. Diflurobenzamide (e.g. Dimilin®25W)
   Use: Impounded tail water, sewage effluent, urban drains and catch basins.
   Limitations: Cannot be applied to wetlands, crops, or near estuaries.

5. Larviciding oils (e.g.Bonide)
   Use: Ditches, dairy lagoons, floodwater. Effective against all stages, including pupae.
   Limitations: Consult with the California Department of Fish and Game for local restrictions.

6. Monomolecular films (e.g. Agnique® MMF)
   Use: Most standing water including certain crops.
   Limitations: Does not work well in areas with unidirectional winds in excess of ten mph.

7. Temephos (e.g. Abate® 2-BG)
   Use: Non-potable water; marshes; polluted water sites

Limitations: Cannot be applied to crops for food, forage, or pasture. This material is an organophosphate compound and may not be effective on some *Culex tarsalis* populations in the Central Valley. May require sampling and testing per General Vector Control NPDES permit requirements if applied to waters of the United States.

Adulticides:

1. Organophosphate compounds
   Note: Many *Culex tarsalis* populations in the Central Valley are resistant at label OP application rates.
   a. Malathion (e.g. Fyfanon® ULV)
      Use: May be applied by air or ground equipment over urban areas, some crops including rice, wetlands.
      Limitations: Paint damage to cars; toxic to fish, wildlife and bees; crop residue limitations restrict application before harvest.
   b. Naled (e.g. Dibrom® Concentrate, Trumpet® EC)
      Use: Air or ground application on fodder crops, swamps, floodwater, residential areas.
      Limitations: Similar to malathion.

2. Pyrethrins (natural pyrethrin products: e.g. Pyrenone® Crop Spray, Pyrenone® 25-5, Evergreen)
   Use: Wetlands, floodwater, residential areas, some crops.
   Limitations: Do not apply to drinking water, milking areas; may be toxic to bees, fish, and some wildlife. Some formulations with synergists have greater limitations.

3. Pyrethroids (synthetic pyrethrin products containing deltamethrin, cyfluthrin, permethrin, resmethrin, sumithrin or etofenprox: e.g. Suspend® SC, Tempo Ultra SC, Aqua-Reslin®, Scourge® Insecticide, Anvil® 10+10 ULV, Zenivex E20, and Duet – which also contains the mosquito exciter prallethrin)
   Use: All non-crop areas including wetlands and floodwater.
   Limitations: May be toxic to bees, fish, and some wildlife; avoid treating food crops, drinking water or milk production.

PESTICIDES USED FOR MOSQUITO CONTROL IN CALIFORNIA

Larvicides

Active Ingredient	Trade name	EPA Reg. No.	Mfgr.	Formulation	Application	Pesticide classification
Bacillus sphaericus, (Bs)	VectoLex CG / WSP	73049-20	Valent BioSciences	Granule Water soluble packet	Larvae	Biorational
Bacillus sphaericus, (Bs)	VectoLex WDG	73049-57	Valent BioSciences	Water dispersible granule	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac WDG	73049-56	Valent BioSciences	Water dispersible Granules	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac 12AS	73049-38	Valent BioSciences	Liquid	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac AS	275-52	Abbott Labs	Liquid	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac G	73049-10	Valent BioSciences	Granule Flake	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac GS	73049-10	Valent BioSciences	Granule Flake	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac Tech. Pdr.	73049-13	Valent BioSciences	Technical powder	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Aquabac 200G	62637-3	Becker Microbial	Granule	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Consume MP	62637-3	Spartan Chemical	Granule	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Aquabac XT	62637-1	Becker Microbial	Liquid	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Bactimos PT	73049-452	Valent BioSciences	Granular flake	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Teknar HP-D	73049-404	Valent BioSciences	Liquid	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Fourstar SBG	85685-1	Fourstar Microbials LLC	Granule	Larvae	Biorational
Bti / Bs combination	Vectomax G, CG, WSP	73049-429	Valent BioSciences	Granular and water soluble packet	Larvae	Biorational
Bti / Bs combination	Fourstar Briquettes	83362-3	Fourstar Microbials LLC	Briquette	Larvae	Biorational
Spinosad	Natular 2EC	8329-82	Clarke	Liquid concentrate	Larvae and pupae	Biorational
Spinosad	Natular G	8329-80	Clarke	Granule	Larvae and pupae	Biorational
Spinosad	Natural G30	8329-83	Clarke	Granule	Larvae and pupae	Biorational
Spinosad	Natular T30	8329-85	Clarke	Tablet	Larvae and pupae	Biorational
Spinosad	Natular XRT	8329-84	Clarke	Tablet	Larvae and pupae	Biorational
Monomolecular film	Agnique MMF	53263-28	Cognis Corp.	Liquid	Larvae and pupae	Surface film
Monomolecular film	Agnique MMF G	53263-30	Cognis Corp.	Granular	Larvae and pupae	Surface film

Monomolecular film	Agnique MMF G Pak 35	53263-30	Cognis Corp.	Water soluble pack	Larvae and pupae	Surface film
Petroleum oil	Masterline Kontrol	73748-10	Univar	Liquid	Larvae and pupae	Surface film
Petroleum oil	BVA 2	70589-1	B-V Assoc.	Liquid	Larvae and pupae	Surface film
Petroleum oil	GB-1111	8329-72	Clarke	Liquid	Larvae and pupae	Surface film
Dimilin	Dimilin 25W	400-465	Uniroyal Chemical	Wettable powder	Larvae	IGR
S-Methoprene	Altosid ALLC	2724-446	Wellmark-Zoecon	Liquid concentrate	Larvae	IGR
S-Methoprene	Altosid ALL	2724-392	Wellmark-Zoecon	Liquid concentrate	Larvae	IGR
S-methoprene	Altosid Briquets	2724-375	Wellmark-Zoecon	Briquet	Larvae	IGR
S-methoprene	Altosid Pellets / WSP	2724-448	Wellmark-Zoecon	Pellet-type granules / water soluble packet	Larvae	IGR
S-methoprene	Altosid SBG	2724-489	Wellmark-Zoecon	Granule	Larvae	IGR
S-methoprene	Altosid XR Briquets	2724-421	Wellmark-Zoecon	Briquet	Larvae	IGR
S-methoprene	Altosid XR-G	2724-451	Wellmark-Zoecon	Granule	Larvae	IGR
Temephos	Abate 2-BG	8329-71	Clarke	Granule	Larvae	OP
Temephos	5% Skeeter Abate*	8329-70	Clarke	Granule	Larvae	OP
Temephos	Abate 4E	8329-69	Clarke	Liquid	Larvae	OP

PESTICIDES USED FOR MOSQUITO CONTROL IN CALIFORNIA

Adulticides

Active Ingredient	Trade name	EPA Reg. No.	Mfgr.	Formulation	Stage	Pesticide classification
Malathion	Fyfanon® ULV	67760-34	Cheminova	Liquid	Adults	OP
Naled	Trumpet™ EC	5481-481	AMVAC	Liquid	Adults	OP
Prallethrin Sumithrin	AquaDuet Adulticide	1021-2562-8329	Clarke	Liquid	Adults	Pyrethroid
Prallethrin Sumithrin	Duet Dual Action Adulticide	1021-1795	Clarke	Liquid	Adults	Pyrethroid
Deltamethrin	Suspend® SC	432-763	Aventis	Liquid	Adults	Pyrethroid
Cyfluthrin	Tempo SC Ultra	432-1363	Bayer	Liquid	Adults	Pyrethroid
Permethrin	Aqua-Kontrol	73748-1	Univar	Liquid	Adults	Pyrethroid
Permethrin	Aqualeur 20-20	769-985	Value Garden Supply	Liquid	Adults	Pyrethroid
Permethrin	Aqua-Reslin®	432-796	Bayer	Liquid	Adults	Pyrethroid
Permethrin	Biomist® 4+4	8329-35	Clarke	Liquid	Adults	Pyrethroid
Permethrin	Biomist® 4+12 ULV	8329-34	Clarke	Liquid	Adults	Pyrethroid
Permethrin	Evoluer 4-4 ULV	769-982	Value Garden Supply	Liquid	Adults	Pyrethroid
Permethrin	Kontrol 2-2	73748-3	Univar	Liquid	Adults	Pyrethroid
Permethrin	Kontrol 4-4	73748-4	Univar	Liquid	Adults	Pyrethroid
Permethrin	Kontrol 30-30	73748-5	Univar	Liquid	Adults	Pyrethroid
Permethrin	Permanone 31-66	432-1250	Bayer	Liquid	Adults	Pyrethroid
Permethrin	Permanone® Ready-To-Use	432-1277	Bayer	Liquid	Adults	Pyrethroid

Permethrin	Perm-X UL 4-4	655-898	Prentiss	Liquid	Adults	Pyrethroid
Pyrethrins	Aquahalt	1021-1803	Clarke	Liquid	Adults	Pyrethroid
Pyrethrins	Evergreen 60-6	1021-1770	MGK	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrenone® 25-5	432-1050	Bayer	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrenone® Crop Spray	432-1033	Bayer	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrocide® 7453	1021-1803	MGK	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrocide® 7395	1021-1570	MGK	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrocide® 7396	1021-1569	MGK	Liquid	Adults	Pyrethroid
Pyrethrins	Pyronyl Crop Spray	655-489	Prentiss	Liquid	Adults	Pyrethroid
Pyrethrins	Pyronyl Oil 525	655-471	Prentiss	Liquid	Adults	Pyrethroid
Pyrethrins	Pyronyl Oil 3610A	655-501	Prentiss	Liquid	Adults	Pyrethroid
Resmethrin	Scourge® Insecticide (4%)	432-716	Bayer	Liquid	Adults	Pyrethroid
Resmethrin	Scourge® Insecticide (18%)	432-667	Bayer	Liquid	Adults	Pyrethroid
Sumithrin	Anvil 2+2 ULV	1021-1687	Clarke	Liquid	Adults	Pyrethroid
Sumithrin	Anvil® 10+10 ULV	1021-1688	Clarke	Liquid	Adults	Pyrethroid
Sumithrin	AquaANVIL	1021-1807	Clarke	Liquid	Adults	Pyrethroid
Etofenprox	Zenivex E4 RTU	2724-807	Wellmark Intl.	Liquid	Adults	Pyrethroid
Etofenprox	Zenivex E20	2724-791	Wellmark, Intl.	Liquid	Adults	Pyrethroid
Lambda-cyhalothrin	Demand CS	100-1066	Syngenta	Liquid	Adults	Pryethroid

Appendix I: Adult Mosquito Control in Urban Areas

Adult mosquito control via ultra low volume (ULV) application is an integral part of an integrated mosquito management program. This response plan recommends the consideration of adult mosquito control to break local virus transmission cycles and reduce the risk of human infection. The following provides guidelines for local agencies considering ground or aerial ULV control of adult mosquitoes. Agencies should ensure they are complying with NPDES permit requirements.

Preparatory steps for aerial application contracts

- Send out request for proposals (RFP) to commercial applicators well in advance of any potential need for actual treatment. Specify required equipment and abilities in the RFP such as: 1) application equipment capable of producing desired droplet spectrum and application rate, 2) aircraft availability time frames (remember FAA requires 2-engine aircraft for applications over urban areas), and 3) the demonstrated ability to apply the chosen product to the target area in accordance with label requirements.
- Outline the desired capabilities and equipment within the RFP such as: 1) onboard real time weather systems, and 2) advanced onboard drift optimization and guidance software.
- Determine in advance whether the vector control agency or contractor will secure and provide pesticides. If the contractor will supply the pesticide, verify their knowledge of and ability to comply with regulations regarding the transport, use, and disposal of all pesticide and containers.
- Enter into a contingency contract with the commercial applicator.
- Consider acquiring non-owned, multiple engine aircraft insurance with urban application endorsement for added protection.
- Determine product and application rate to be used, along with a contingency plan. The product choice may be subject to change depending on product availability, the determination of resistance, labeling restrictions, environmental conditions, or other unforeseen factors.

Preparatory steps for ground-based applications

- Ensure that application equipment has been properly calibrated and tested for droplet size and flow rate. The vector control agency should have enough equipment, operators, and product available to finish the desired application(s) between sunset and midnight, or within 2-3 hours pre-sunrise (or when mosquitoes are demonstrated to be most active) to maximize efficacy.
- Ensure that vehicles are equipped with safety lighting and appropriate identifying signs; use sufficient personnel.
- Contact local law enforcement and provide them with locations to be treated and approximate time frames.
- Consider using lead and trailing vehicles particularly if the area has not been treated before and personnel are available.

Implementing an aerial application contract

- Contact commercial applicator and determine availability.
- Review long-term weather forecasts. Ideally applications should be scheduled during periods of mild winds to avoid last minute cancellations.

Contractor should:

- Contact Local Flight Standards District Office (FSDO) for low flying waiver.
- Arrange for suitable airport facilities.
- Contact local air traffic control.
- Locate potential hazards prior to any application and implement a strategy to avoid those hazards during the application – often in darkness.
- Provide equipment and personnel for mixing and loading of material (if previously agreed upon in contract).
- Register with applicable County Agricultural Commissioner's office.

Vector control agency should:

- Delineate treatment block in a GIS format and send to contractor.
- Identify areas that must be avoided during an application and include detailed maps of those areas to contract applicators (e.g. open water, registered organic farms, any area excluded by product label).
- Send authorization letter to FSDO authorizing contractor to fly on the agency's behalf; contractor should provide contact information and assistance.
- Send map of application area and flight times / dates to local air traffic control; contractor should provide contact information and assistance.
- Consult with County Agricultural Commissioner's office. Commissioner's office can provide guidance on contacting registered bee keepers and help identify any registered organic farms that may need to be excluded from application.
- If vector control agency is providing material, ensure adequate quantity to complete mission and that the agency has means to transport material.

Efficacy evaluation for aerial or ground based application

- Choose appropriate method(s) for evaluating efficacy of application
  - Determine changes in adult mosquito population via routine or enhanced surveillance.
  - Conduct three day pre and post-trapping in all treatment and control areas.
  - Set out bioassay cages with wild caught and laboratory reared (susceptible) mosquitoes during application.
- Ensure adequate planning so surveillance staff is available and trained, equipment is available, and trap / bioassay cage test locations are selected prior to application.
- Ensure efficacy evaluation activities are timed appropriately with applications.
- Enlist an outside agency such as CDPH and/or university personnel to help evaluate efficacy of application as appropriate.

Actions at time of application

- Confirm application rate with contractor.
- Confirm treatment block.
- Coordinate efficacy evaluations.

Public notification

Notification of the public prior to a mosquito control pesticide application by a vector control agency signatory to a Cooperative Agreement with CDPH, or under contract for such agency is not a legal requirement in California (California Code of Regulations – Title 3: Food and Agriculture: Division 6. Pesticides and Pest Control Operations: Section 6620a). However, public notification of pending adult mosquito control is recommended as early as possible prior to the treatment event.

Basic notification steps

- Provide notification of pending application as early as possible.
- Post clearly defined treatment block map online or through appropriate media outlet.
- Post product label and material safety data sheet (MSDS) online or through appropriate media outlet.
- Post and/or have available scientific publications regarding the efficacy of aerial or ground based applications (as appropriate), including effects on non-target organisms and risk-assessments.

Public relations considerations

- Ensure staffing is adequate to handle a significant increase in phone calls.
- Ensure website capability is adequate to handle a rapid increase in visitors.
- Train personnel answering phones to address calls from citizens concerned about personal and environmental pesticide exposure.
- Ensure adequate follow-through for calls related to sporting events, concerts, weddings, and other outdoor events that may be scheduled during the application and within the treatment block

Appendix J: Websites Related to Arbovirus Surveillance, Mosquito Control, Weather Conditions and Forecasts, and Crop Acreage and Production in California

Website	URL	Available information
California West Nile Virus Website	http://westnile.ca.gov	Up to date information on the spread of West Nile virus throughout California, personal protection measures, online dead bird reporting, bird identification charts, mosquito control information and links, clinician information, local agency information, public education materials.
UC Davis Center for Vectorborne Diseases	http://cvec.ucdavis.edu/	Frequently updated reports and interactive maps on arbovirus surveillance and mosquito occurrence in California.
Mosquito and Vector Control Association of California	http://www.mvcac.org	News, membership information, event calendars, and other topics of interest to California's mosquito control agencies.
California Vectorborne Disease Surveillance Gateway	http://gateway.calsurv.org	Data management system for California's mosquito control agencies.
California Data Exchange Center	http://cdec.water.ca.gov	Water-related data from the California Department of Water Resources, including historical and current stream flow, snow pack, and precipitation information.
UC IPM Online	http://www.ipm.ucdavis.edu	Precipitation and temperature data for stations throughout California; also allows calculation of degree-days based on user-defined data and parameters.
National Weather Service – Climate Prediction Center	http://www.cpc.ncep.noaa.gov/products/predictions/	Short-range (daily) to long-range (seasonal) temperature and precipitation forecasts. Also provides El Niño-related forecasts.
California Agricultural Statistics Service	http://www.nass.usda.gov/Statistics_by_State/California	Crop acreage, yield, and production estimates for past years and the current year's projections. Reports for particular crops are published at specific times during the year – see the calendar on the website.
State Water Resources Control Board	http://www.swrcb.ca.gov/water_issues/programs/npdes/aquatic.shtml	National Pollutant Discharge Elimination System (NPDES) permit for vector control information.
US Environmental Protection Agency – Mosquito Control	http://www.epa.gov/pesticides/health/mosquitoes	Describes the role of mosquito control agencies and products used for mosquito control.
US Centers for Disease Control and Prevention – West Nile Virus	http://www.cdc.gov/ncidod/dvbid/westnile/index.htm	Information on the transmission of West Nile virus across the United States, viral ecology and background on WNV, and personal protection measures in various languages.

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Photo Courtesy Sacramento-Yolo MVCD

Best Management Practices for Mosquito Control in California

Recommendations of the
California Department of Public Health
and the
Mosquito and Vector Control Association of California

MVC
Association of California

July 2012

CDPH
California Department of Public Health

BEST MANAGEMENT PRACTICES
FOR MOSQUITO CONTROL IN CALIFORNIA

An electronic version of this manual and the companion document “Best Management Practices for Mosquito Control on California State Properties” are available from the California West Nile virus website at http://www.westnile.ca.gov/resources.php. Please see Table 1, page 22, for a list of California mosquito control agencies or visit http://mvcac.org.

For more information, please contact:

Vector-Borne Disease Section
California Department of Public Health
vbds@cdph.ca.gov
(916) 552-9730
http://www.cdph.ca.gov
http://www.westnile.ca.gov

Purpose of this Manual

This manual provides landowners with Best Management Practices (BMPs) for mosquito control. The term BMP is used to describe actions landowners can take to reduce mosquito production from permanent water sources, reduce or eliminate mosquito production from temporary water sources, and reduce the potential for disease transmission to humans on their property.

General Recommendations

- **Implement universal BMPs**
  - Use personal protective measures
  - Eliminate unnecessary standing water

- **Identify and implement applicable mosquito control BMPs**
  - Reduce stagnation by providing water flow and manage vegetation in ponds or other water bodies.
  - Collaborate with local vector control agencies to develop and implement appropriate Integrated Pest Management (IPM) strategies that are most suitable for specific land-use type(s).

Use personal protective measures when potentially exposed to adult mosquitoes.

Eliminate unnecessary standing water, reduce stagnation by providing water flow, and manage vegetation in ponds or other water bodies.

Collaborate with local vector control agencies to coordinate activities on your property within a larger Integrated Pest Management mosquito control program.

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Executive Summary

The California Department of Public Health (CDPH) in collaboration with the Mosquito and Vector Control Association of California (MVCAC) developed this Best Management Practices (BMPs) plan to promote mosquito control on California properties, and enhance early detection of West Nile virus (WNV).

This plan describes mosquito control BMPs to be implemented by property owners and managers. These recommended practices, when properly implemented, can reduce mosquito populations through a variety of means including: 1) reducing or eliminating breeding sites, 2) increasing the efficacy of biological control, and 3) decrease the amount of pesticides applied while increasing the efficacy of chemical control measures. It is critical that property owners and managers communicate regularly with local vector control agencies regarding control practices on lands that are located within or near a local agency's jurisdiction. Local vector control agencies may have more specific policies regarding the implementation of BMPs and other control operations, which may include use of enforcement powers authorized by the California Health and Safety Code.

There are many different BMPs included in this document and they are intended to provide overall guidance to reduce mosquito production on properties throughout California, though not all mosquito sources and land uses will be addressed in this document. If it is deemed necessary, site-specific BMP plans may be developed in collaboration with CDPH and the respective local mosquito and vector control agency.

Effective mosquito-borne disease surveillance and mosquito control to protect public health are dependent upon factors that may fluctuate temporally and regionally. Such factors include mosquito and pathogen biology, environmental factors, land-use patterns, resource availability; strategies that incorporate BMPs are the most effective means by which mosquito control can be conducted and individualized to specific situations. Best management practices included in this plan emphasize the fundamentals of integrated pest management (IPM) which include:

1. Knowledge of mosquito species composition and corresponding mosquito behavior and habitat, for both immature and adult stages.

2. Detecting and monitoring WNV activity by testing mosquitoes, birds, sentinel chickens, horses, and humans. Identifying the mosquito species present, locations, densities, and disease potential.

3. Managing mosquito populations by source reduction, habitat modification, and biological control (e.g., introduced predators and parasites). Pesticides are used to target immature and, when indicated, adult stages of the mosquito. Mosquito control products are selected and applied in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment.

4. Educating the general public about reducing mosquito production and minimizing their risk of exposure to WNV.

RECOMMENDATIONS FOR PROPERTY OWNERS AND MANAGERS

- Use this plan to identify and implement appropriate Best Management Practices to control mosquitoes.
- Eliminate unnecessary standing water, reduce stagnation by providing water flow, and manage vegetation in ponds or other water bodies.
- Collaborate with local vector control agencies to develop and implement appropriate integrated pest management strategies that are most suitable for specific land-use type(s).
- Ensure individuals use personal protective measures when potentially exposed to adult mosquitoes.

Introduction

Controlling mosquitoes is critical to maintaining both a high quality of life and protecting people from mosquito-transmitted (vectored) diseases such as West Nile virus (WNV). In many parts of California, residents have voted to form local mosquito control programs or agencies. As a result, approximately half the land area and 85% of the population of California are within the boundaries of a mosquito control program. Landowners and land managers have a responsibility to minimize mosquito production on their lands and play a key role in reducing mosquito populations throughout the State, regardless whether their property is inside or outside the jurisdiction of a mosquito control program. Information about mosquito surveillance, mosquito-borne diseases, and mosquito control is available in Appendices A and B.

Best Management Practices (BMPs) are defined as actions landowners can take to reduce or eliminate mosquito production from water sources on their property in an environmentally and fiscally responsible manner, and to reduce the potential for transmission of disease from mosquitoes to humans.

Each property is unique, and the BMPs listed in this manual will apply to some properties, but not others. Landowners should implement universally applicable BMPs and after evaluating their own property, also employ the mosquito control BMPs that are applicable to their situation.

Landowner Responsibility

According to the California Health and Safety Code, landowners in California are legally responsible to abate (eliminate the source of) a public nuisance arising from their property, including mosquitoes [H&S Code Sections 2001 - 4(d); 2002; 2060 (b)]. In areas that are within the jurisdictional boundaries of a mosquito control program, landowners should work with staff to address mosquito problems, particularly in areas where irrigation is used for agricultural purposes. Landowners that are not within the jurisdictional boundary of an established mosquito control program should seek advice from the nearest mosquito control agency or health department. Landowners may also contact the California Department of Public Health (CDPH) or consult the CDPH West Nile virus website for additional information about mosquitoes and mosquito control. http://www.westnile.ca.gov/resources.php.

Mosquito control programs have substantial authority to access private property, inspect known or suspected sources of mosquitoes, abate the source of a mosquito problem, and charge the landowner for work performed and/or charge fees if a landowner is unwilling or unable to address a mosquito problem arising from their property [H&S Code sections 2060-2067, 100170, and 100175]. Applicable sections of the California Health and Safety Code are summarized in Appendix C.

Mosquito Biology

The more than 50 species of mosquitoes in California share one common life history trait: the mosquito life cycle requires standing water. Management of standing water is the key to most of the mosquito control BMPs presented in this manual and is one of the oldest and most cost effective forms of mosquito control.

Mosquito species are broadly separated into two groups according to where they lay eggs, floodwater mosquitoes and standing water mosquitoes. Adult female floodwater mosquitoes lay eggs on mud or previously submerged vegetation. The eggs may remain dormant for days, months, or even years until they are flooded, at which time larvae hatch. Standing water mosquitoes lay eggs on the water surface. The eggs float on the surface for a few hours to a few days until the larvae hatch into the water.

Floodwater mosquito larval development (breeding) sites include irrigated pastures, rice fields, seasonally flooded duck clubs and other managed wetlands, tidal wetlands, riparian corridors, and snowmelt pools. These intermittent or seasonally flooded habitats can be among the most productive sources of mosquitoes because they are often free of natural predators.

Standing water mosquito breeding sites include artificial containers, treeholes, catch basins, open ditches, retention/detention ponds, natural or constructed ponds and wetlands, stormwater management devices, and along the edges of flowing streams. Sources are found everywhere from highly urban areas to natural wetlands and often produce multiple generations of mosquitoes each season. In southern California, urban sources can produce some species of mosquitoes year round.

Landowners or land managers can identify the presence of immature mosquitoes in water on their property. Mosquito larvae breathe air from above the water surface and most hang at an angle from or lay parallel with the surface of the water while consuming small bits of organic matter. When disturbed, larvae swim down into the water column in a serpentine motion. Mosquitoes may live as larvae from a couple of days to more than a month depending on the species, water temperature, and the amount of food available.

Mosquitoes then go through a non-feeding stage called a pupa. During this stage the mosquito changes into the winged adult form. The easily identified comma-shaped pupae hang from the water surface and move down through the water column in a rolling or tumbling motion when disturbed. This life stage typically lasts about a day, with the mosquito emerging from the back of the pupal case (above the water) as a flying adult. (See Figure 1: Mosquito Life Cycle).

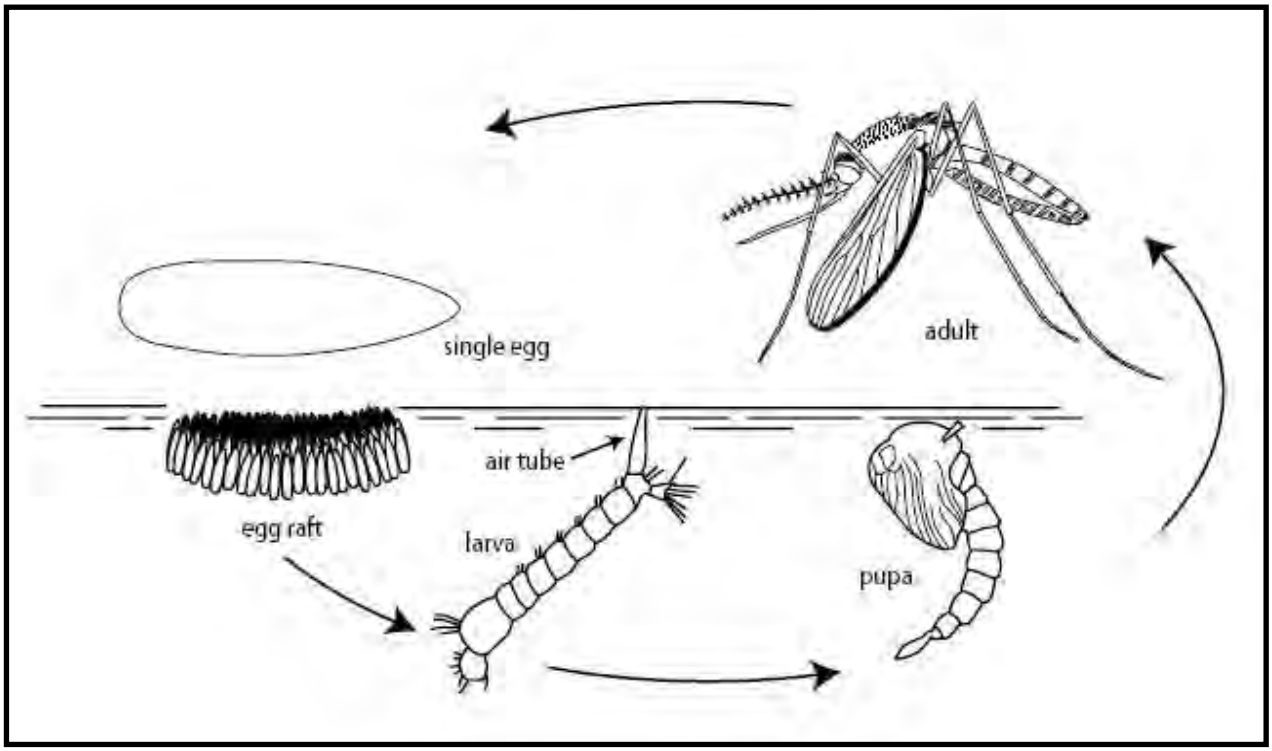

Figure 1. The life cycle of all mosquito species consists of four stages: egg, larva, pupa, and adult.

All adult mosquitoes feed on plant nectar; however blood is essential for female mosquitoes to produce eggs. To take a blood meal, the female's mouth parts pierce the skin, inject saliva, and suck blood out. It is through the injection of saliva that a mosquito causes the typical itchy bump and can infect a person or domestic animal with a disease causing organism. Depending on an individual's immune response, even a single bite can be a significant nuisance.

For more information on mosquito biology and key mosquito species found in California, please see Appendix D.

For additional information on the larval habitats of California mosquitoes, please see Appendix E.

Best Management Practices (BMPs)

Mosquito Control Best Management Practices At-A-Glance

- Eliminate artificial mosquito sources.
- Ensure man-made temporary sources of surface water drain within four days 96 hours) to prevent development of adult mosquitoes.
- Control plant growth in ponds, ditches, and shallow wetlands.
- Design facilities and water conveyance and/or holding structures to minimize the potential for producing mosquitoes.
- Use appropriate bio-rational products to control mosquito larvae.
- Use personal protective measures to prevent mosquito bites.

Each property is unique. Landowners should implement universally applicable mosquito control BMPs, and after evaluating their own property, also employ the mosquito control BMPs that are applicable to their property and circumstances. Using appropriate BMPs is an efficient and effective way to help prevent a mosquito problem.

Universally Applicable Mosquito Control BMPs

Eliminate Artificial Mosquito Breeding Sites and Harborage

- Examine outdoor areas and drain temporary and unnecessary water that may stand longer than 96 hours.
- Dispose of unwanted or unused artificial containers.
- Properly dispose of old tires.
- If possible, drill drainage holes, cover, or invert any container or object that holds standing water that must remain outdoors. Be sure to check for containers or trash in places that may be hard to see, such as under bushes or buildings.
- Clean clogged rain gutters and storm drains. Keep outdoor drains flowing freely and clear of leaves, vegetation, and other debris.
- Aerate ornamental ponds to avoid letting water stagnate.
- Change water in birdbaths, fountains, and animal troughs at least once per week.
- Ensure rain and/or irrigation water does not stand in plant containers, trash cans, boats, or other containers on commercial or residential properties.
- Regularly chlorinate swimming pools and keep pumps and filters operating. Unused or unwanted pools should be kept empty and dry, or buried.
- Maintain irrigation systems to avoid excess water use and runoff into storm drains.
- Minimize sites mosquitoes can use for refuge (harborage) by thinning branches, trimming and pruning ornamental shrubs and bushes, and keeping grass mowed short.

Use Personal Protective Measures

- Apply an EPA-registered mosquito repellent when outdoors; especially around dusk and dawn when mosquitoes are most active (see Appendix F for additional information on insect repellents).
- Wearing loose-fitting protective clothing including long sleeves and pant legs.
- Install and properly maintain fine mesh screens on windows and doors to prevent mosquito entry into homes.

Provide Mosquito Management Related Information to Property Managers

- Off-site landowners should provide property managers with basic information about mosquitoes and appropriate measures to minimize mosquito habitats.

Contact Local Mosquito Control Program

- Contact the local mosquito control program to evaluate your property for mosquito breeding sites and work cooperatively to prevent a mosquito problem on your property. A contact list for mosquito control programs is provided in Table 1.

Where local mosquito control programs do not exist, landowners may contact CDPH for assistance or consult the California West Nile virus website for additional information about mosquito control: http://www.westnile.ca.gov/resources.php

Mosquito Control BMPs for Residential and Landscaped Properties

Many residential and commercial properties have potential mosquito sources around buildings and grounds associated with excess or poorly managed irrigation, poor drainage, and miscellaneous landscape features. Mosquitoes can develop in the standing water associated with over-irrigation, irrigation breaks and/or runoff, clogged gutters, stormwater management structures, ornamental ponds, swimming pools, trash cans and flower pots, low areas or holes in turf where water collects and stands and low areas underneath pier and beam homes or buildings.

Mosquito sources can be minimized by taking precautions such as regular inspection and proper maintenance of irrigation systems and other water features, and elimination of unwanted standing water.

- Avoid over-irrigating to prevent excess pooling and runoff.
- Routinely inspect, maintain, and repair irrigation system components.

- All underground drain pipes should be laid to grade to avoid low areas that may hold water for longer than 96 hours.
- Back-fill tire ruts or other low areas that hold water for more than 96 hours.
- Improve drainage channels and grading to minimize potential for standing water.
- Keep drainage ditches free of excessive vegetation and debris to provide rapid drainage.
- Check and repair leaky outdoor faucets.
- Report any evidence of standing water to responsible maintenance personnel.
- Use waterfalls, fountains, aerators and/or mosquitofish in ponds and ornamental water features. Land owners must consult with the local mosquito control agencies or California Fish and Game regarding proper use of mosquitofish.
- Prevent mosquito breeding in rain barrels by properly screening all openings, preventing mosquito access to the stored water.
- For ponds and ornamental water features where mosquitofish cannot be used, landowners should use one of several readily available larval mosquito control products to treat water when they see immature mosquitoes.

Landowners should also review the stormwater runoff section of this manual because building rooftops, parking lots, etc. may have associated stormwater management features that produce mosquitoes.

Mosquito Control BMPs for Rural Properties

Mosquito breeding on rural properties is highly variable due to differences in location, terrain, and land use. This list is intended to provide general guidance, not site-specific requirements. BMPs that are most applicable and relevant to a specific mosquito source may be selected from the list and incorporated into the overall property management plan. Ideally, activities should be coordinated with those of a local mosquito control program.

Flood irrigation is a common practice in rural areas throughout California and always poses the potential for creating mosquito breeding sites. Mosquitoes commonly develop within irrigation infrastructure including in ditches clogged with vegetation, irrigation tail water areas and return sumps, blocked ditches or culverts, vegetated ditches; and leaking irrigation pipes, head gates, pumps, stand pipes, etc. The fields, orchards, and pastures being irrigated may also produce mosquitoes, particularly where natural undulation or poor grading create low lying areas where water collects and stands.

Recommendations for rural properties are based on “Mosquito Control Best Management Practices” produced by the Sacramento-Yolo Mosquito and Vector Control District, and from Lawler and Lanzaro (2005).

Mosquito Control BMPs for Ditches and Drains

- Construct or improve large ditches to a slope of at least 2:1 (vertical: horizontal) and a minimum 4 foot wide bottom. Consider a 3:1 slope or greater to discourage burrowing animal damage, potential seepage problems, and prevent unwanted vegetation growth.
- Keep ditches clean and well-maintained. Periodically remove accumulated sediment and vegetation. Maintain ditch grade and prevent areas of standing water.
- Design irrigation systems to use water efficiently and drain completely to avoid standing water.
- Prevent wet areas associated with seepage by repairing leaks in dams, ditches, and drains.

Mosquito Control BMPs for Irrigated Pastures and Cropland

- Grade to eliminate standing water from pastures and fields. Use Natural Resource Conservation Service (NRCS) guidelines: Laser leveling and periodic maintenance may be needed to allow proper drainage, efficient water flow, and reduce low-lying areas where standing water may accumulate.
- Reuse wastewater through return flow systems to effectively minimize mosquito production and conserve water. Eliminate and reuse excess water that may typically stagnate and collect at lower levels of irrigated fields.
- Irrigate only as frequently as is needed to maintain proper soil moisture. Check soil moisture regularly.
- Drain water as quickly as possible following irrigation. Check slopes may be used to direct water movement and drainage. Drainage ditches may be used to remove water from the lower end of the field.
- Install surface drains to remove excess water that collects at lower levels of irrigated fields.
- Inspect fields for drainage and broken checks to see whether re-leveling or reconstruction of levees is needed. Broken checks create cross-leakage that may provide habitat for mosquitoes.
- If possible, use closed conduits instead of open canals for water conveyance.
- Do not over fertilize. Over-fertilization can leach into irrigation run-off making mosquito production more likely in ditches or further downstream.
- When possible, use sprinklers or drip systems rather than flood irrigation.
- Keep animals off the pasture while the soil is soft. Mosquito habitat is created in irrigated pastures when water collects in hoof prints.

Mosquito Control BMPs for Rice Fields

Flooded rice fields can always support the development of mosquitoes. As the rice stand develops and grows denser, the production of mosquitoes tends to increase while the ability for chemical control agents to penetrate the canopy decreases. The BMPs

presented in this section attempt to balance the needs of the grower with the need to control mosquitoes.

In California there is a long-standing cooperative effort among the Rice Commission, individual growers, and mosquito control agencies to manage mosquitoes on rice lands. Close cooperation between growers and vector control is particularly important with organic rice producers. With severe limits on chemical control options and greater expense for organic-compatible larvicides, organic rice growers should implement as many mosquito control BMPs as possible.

- Wherever feasible, maintain stable water levels during mosquito season by ensuring constant flow of water into ponds or rice fields to reduce water fluctuation due to evaporation, transpiration, outflow, and seepage.
- Inspect and repair levees to minimize seepage.
- Drain and fill in borrow pits and seepage areas external to the fields.
- Wherever feasible, maintain at least 4" – 6" (10-15 cm) of water in the rice field after rice seedlings have begun to stand upright. Any drainage should be coordinated with local vector control (where possible). Restocking of mosquitofish or use of alternative mosquito control measures should be instituted as soon as possible when fields are re-flooded.
- Whenever feasible, remove vegetation on the outer-most portions of field levees and checks, specifically where they interface with standing water.
- Control algae and weed growth as effectively as possible.
- Communicate frequently with your local mosquito control program regarding your crop management activities.
- Wherever feasible, maintain borrow pits (12" – 18" deep) (30-45 cm) on both sides of each check throughout rice fields to provide refuge for mosquitofish during low water periods.
- If a pyrethroid pesticide is to be applied to the fields stocked with mosquitofish, contact your local mosquito control program for advice on minimizing fish mortality.
- If a pesticide is applied, fields should be inspected for mosquitofish afterward and if needed, fish should be restocked as soon as feasible.

Mosquito Control BMPs for Dairies and Animal Holding Operations

Frequently infrastructure associated with dairies, feedlots, or other animal holding facilities can produce mosquitoes. Watering troughs and irrigated fields associated with the operation can create mosquito problems. Animal washing areas may also create mosquito problems, particularly drains and ditches, sumps, ponds, and wastewater lagoons.

The following activities can reduce mosquito production and simplify control activities around dairies and animal holding operations:

- All holding ponds should be surrounded by lanes of adequate width to allow safe passage of mosquito control equipment. This includes keeping the lanes clear of any materials or equipment (e.g. trees, calf pens, hay stacks, silage, tires, equipment, etc.).
- If fencing is used around the holding ponds, it should be placed on the outside of the lanes with gates provided for vehicle access.
- Large ponds should be divided into a series of smaller ponds that can be drained for removal of solid waste material.
- Ponds and lagoons should be narrow enough to allow solid waste removal after drying.
- All interior banks of the holding ponds should have a grade of at least 2:1.
- If possible, an effective solids separation system should be utilized such as a mechanical separator or two or more solids separator ponds. If ponds are used, they should not exceed 60' (18m) in surface width.
- Drainage lines should never by-pass the separator ponds, except those that provide for normal corral run-off and do not contain solids.
- When possible, floating debris should be removed from ponds prior to crust formation.
- If a thick crust exists (grass growing on crust), it should be left intact until the pond can be drained and the solid material removed.
- Vegetation should be controlled regularly to prevent emergent vegetation and barriers to access. This includes access lanes, interior pond embankments, and any weed growth that might become established within the pond surface.
- Dairy wastewater discharge for irrigation purposes should be managed so it does not stand for more than 4 days.
- Tire sidewalls or other objects that will not hold water should be used to hold down tarps (e.g. on silage piles). Whole tires or other water-holding objects should be replaced.

Mosquito Control BMPs for Wetlands

Wetlands are an important source of mosquito production on public and privately owned lands. Under the California Wildlife Protection Act, the term "wetlands" is defined as any lands which may be covered periodically or permanently with shallow water, which

include freshwater and saltwater marshes, open or closed brackish water marshes, swamps, mudflats, fens, and vernal pools (Fish & Game Code Section 2785). Many wetlands are protected by federal and state laws.

By definition, “natural” wetlands are not intensely managed and options for implementing mosquito control BMPs in these areas are very limited. Even in managed wetlands, not all BMPs listed below may be suitable for use in all wetlands. It is the responsibility of the landowner to become informed on timing and extent of acceptable activities in a given wetland habitat. Intermittently or seasonally flooded wetlands can produce formidable numbers of mosquitoes, whereas well-managed semi-permanent and permanent wetlands usually produce fewer mosquitoes because of their limited acreage, stable water levels, and abundance of natural predators of mosquito larvae.

Information within this section has been partially adapted from Kwasny et al. (2004). Based on the site activities and potential for mosquito production, the existing BMPs may need to be modified or supplemented to address public health risk, goals and management strategy issues, and requirements of California Department of Fish and Game (DFG), the local mosquito and vector control program, and CDPH.

Due to the delicate and sometimes protected wetlands ecosystems, landowners, biologists, managers, and staff from mosquito control programs should collaborate to control mosquitoes. Source reduction and source maintenance can be combined with the judicious use of specific larvicides to minimize mosquito production from these wetlands.

General Mosquito Control BMPs for Wetlands

- Manage vegetation routinely; activities such as annual thinning of rushes and cattails and removing excess vegetative debris enables natural predators to hunt mosquito larvae more effectively in permanent wetlands. Vegetation in shallow, temporary wetlands can be mowed when dry.
- Time flooding of seasonal wetlands to reduce overlap with peak mosquito activity.
- Flood wetlands from permanent-water sources containing mosquito predators (e.g., mosquito-eating fish or invertebrate predators) to passively introduce mosquito predators. Permanent wetlands and brood ponds can be stocked with mosquitofish or native predatory species.
- Maintain permanent or semi-permanent water within the wetland to maintain populations of larval mosquito predators. Discourage the use of broad spectrum pesticides.
- Use fertilizers conservatively and manage irrigation drainage to prevent or minimize fertilizer and/or manure flowing into wetlands. Buffers between agriculture fields and wetlands should be established.
- Comply with all Federal and State Environmental Laws and the California Health and Safety Code to prevent environmental harm while reducing or eliminating mosquito production.

Mosquito Control BMPs for Design and Maintenance of Wetlands

- Provide reasonable access on existing roads and levees to allow for monitoring, abatement, and implementation of BMPs. Make shorelines of natural, agricultural, and constructed water bodies accessible for periodic maintenance, mosquito monitoring and abatement procedures, and removal of emergent vegetation.
- Construct, improve, or maintain ditches with 2:1 slopes and a minimum 4 foot (1.2 m) width at the bottom. Consider a 3:1 slope or greater to discourage burrowing animal damage, potential seepage problems, and prevent unwanted vegetation growth.
- Construct, improve, or maintain levees to quality standards that ensure stability and prevent unwanted seepage. Ideally build levees with >3:1 slopes and > 80% compaction; consider 5:1 slope or greater in areas prone to overland flooding and levee erosion.
- Provide adequate water control structures for complete draw-down and rapid flooding.
- When possible, include independent inlets and outlets in the design of each wetland unit.
- Construct or enhance swales so they are sloped from inlet to outlet and allow maximum draw-down.
- Excavate deep channels or basins to maintain permanent water areas (>2.5 feet deep) within a portion of seasonal managed wetlands. This provides year-round habitat for mosquito predators that can inoculate seasonal wetlands when they are irrigated or flooded.

Wetland Infrastructure Maintenance Mosquito Control BMPs

- Inspect levees at least annually and repair as needed.
- Periodically inspect, repair, and clean water control structures.
    - Remove all debris, including silt and vegetation, which can impede drainage and water flow.
    - Ensure water control structures are watertight to prevent unnecessary water flow or seepage.
- Regularly remove trash, silt and vegetation from water delivery ditches to allow efficient water delivery and drainage.
    - Remove problem vegetation that inhibits water flow using herbicides or periodic dredging.
    - If possible, use closed conduits instead of open canals for water conveyance.
- Periodically test and repair pumps used for wetland flooding to maximize pump output.

Water Management Mosquito Control BMPs for Seasonal Wetlands

- Timing of flooding
    - Delay or “phase” fall flooding of wetlands as long as possible in consultation with local vector control agencies. Fall flooding is known to produce large numbers of mosquitoes and/or those in close proximity to urban areas to minimize late season mosquito production.
    - Strategically locate wetlands identified for early flooding. Wetlands that are flooded in early fall should not be close to urban areas or historically produce great numbers of mosquitoes.
    - When possible, water in managed wetlands should be drawn-down in late March or early April.
    - Use a flood-drain-flood regime to control floodwater mosquitoes; flood to trigger hatching of dormant mosquito eggs, drain water and larvae into an area where they can be easily treated, drowned in moving water, or consumed by predators, and immediately re-flood wetland. This water management regime should be used only when it does not conflict with water quality regulations.
- Speed of flooding
    - Flood wetlands as quickly as possible to reduce the potential for large numbers of mosquitoes. Coordinate flooding with neighbors and/or the water district to maximize flood-up rate.
- Water source
    - Flood wetlands with water from permanent water sources containing mosquito predators (i.e., mosquito-eating fish or invertebrate predators) to passively introduce mosquito predators. Permanent wetlands and brood ponds used as flooding sources can be stocked with mosquito-eating fish or maintained to encourage natural predator populations.
    - Maintain a separate permanent water reservoir that conveys water to seasonal wetlands that provides year-round habitat for mosquito predators that can inoculate seasonal wetlands when they are irrigated or flooded.
- Frequency and duration of irrigation
    - When possible, reduce the number and duration of irrigations to minimize standing water. The need to irrigate should be evaluated based on spring habitat conditions and plant growth. If extended duration irrigation

(generally 14-21 days) is considered for weed control (e.g., cocklebur),
    - additional measures to offset the potential for increased mosquito production may be needed.
    - Irrigate managed wetlands before soil completely dries after spring draw-down to discourage floodwater mosquitoes from laying eggs in the dry, cracked substrate.
    - Drain irrigation water into ditches or other water sources with mosquito predators instead of nearby dry fields.
    - Maintain high ground water levels by keeping channels or deep swales permanently flooded for subsurface irrigation to reduce the amount of irrigation water needed during the mosquito season.
- Communicate with your local mosquito control agency (if there is one)
    - Advise your local mosquito control agency when you intend to flood so that they can make timely applications of larvicide if necessary.
- Emergency preparedness
    - Whenever feasible, have an emergency plan that provides for immediate drainage into acceptable areas if a mosquito-borne disease related public health emergency occurs.

Vegetation Management Mosquito Control BMPs

- Control floating vegetation conducive to mosquito production (i.e., water hyacinth, water primrose, parrot feather, duckweed, and filamentous algae mats).
- Perform routine maintenance to reduce problematic emergent plant densities to facilitate the ability of mosquito-eating fish to move through vegetated areas and allow good penetration of chemical control agents.
- Manage vegetation based on local land management objectives and associated habitat uses to minimize mosquito production. Methods of vegetation control for managed wetlands include mowing, burning, disking, and grazing.
- Manage the spread and density of invasive, non-native emergent wetland vegetation to increase native plant diversity, increase the mobility of larval mosquito predators, and allow for more efficient penetration of chemical control agents.

Additional Water Management BMPs for Permanent Wetlands

- Maintain stable water levels in wetlands that are flooded during summer and early spring to prevent intermittent flooding of shoreline areas favorable to mosquito production. Water level fluctuation can be minimized by continuing a constant flow of water into the wetland.
- Circulate water to avoid stagnation (e.g., provide a constant influx of water equal to the net loss or discharge of water).
- Maintain water depths as deep as possible (18” – 24” [45-60 cm] or more) during the initial flood-up to minimize shallow habitats preferred by mosquito larvae. Shallow water levels can be maintained outside of the mosquito breeding season.

Additional Mosquito Control BMPs for Saltwater Marsh

- Improving water flow through the wetland system minimizes stagnant water and facilitates movement of fish and other natural predators. For example, mosquitoes in coastal tidal wetlands can be managed by constructing and maintaining ditches that drain off the water when the tide falls.

Mosquito Control BMPs for Stormwater Management and Associated Infrastructure

Federal and state environmental regulations require mitigation of the harmful effects of runoff water from storms, irrigation or other sources prior to entering natural waterways from point and non-point sources. Mitigation may include water capture, slowing flow velocity, reducing volume, and removal of pollutants. The term “stormwater” is used as a generic term for runoff water, regardless of source.

Stormwater infrastructure typically includes conveyance systems (e.g. drain inlets, catch basins, pipes, and channels), storage and infiltration systems (e.g. flood control basins, percolation basins), and more recently, structural treatment devices designed and installed specifically to remove suspended and dissolved pollutants from runoff (e.g., vegetated swales, dry detention basins, ponds and constructed wetlands, media filtration devices, and trash capturing devices). The size and variability of stormwater infrastructure, inconsistent quantity and timing of water flows, and propensity to carry and accumulate sediment, trash, and debris, makes these systems highly conducive to holding areas of standing water ideal for production of mosquitoes. Identification of the potential mosquito sources (often belowground) found within stormwater infrastructure is often more difficult than the solutions needed to minimize mosquitoes. Some of the information within this section has been adapted from Metzger (2004).

General Stormwater Management Mosquito Control BMPs

- Manage sprinkler and irrigation systems to minimize runoff entering stormwater infrastructure.
- Avoid intentionally running water into stormwater systems by not washing sidewalks and driveways, washing cars on streets or driveways, etc.
- Inspect facilities weekly during warm weather for the presence of standing water or immature mosquitoes.
- Remove emergent vegetation and debris from gutters and channels that accumulate water.
- Consider mosquito production during the design, construction, and maintenance of stormwater infrastructure.
- Design and maintain systems to fully discharge captured water in 96 hours or less.
- Include access for maintenance in system design.

- Design systems with permanent water sources such as wetlands, ponds, sumps, and basins to minimize mosquito habitat and plan for routine larval mosquito inspection and control activities with the assistance of a local mosquito control program.

Stormwater Conveyance

- Provide proper grades along conveyance structures to ensure that water flows freely.
- Inspect on a routine basis to ensure the grade remains as designed and to remove accumulations of sediment, trash, and debris.
- Keep inlets free of accumulations of sediment, trash, and debris to prevent standing water from backing up on roadways and gutters.
- Design outfalls to prevent scour depressions that can hold standing water.

Stormwater Storage and Infiltration Systems (Aboveground)

- Design structures so that they do not hold standing water for more than 96 hours to prevent mosquito development. Features to prevent or reduce the possibility of clogged discharge orifices (e.g., debris screens) should be incorporated into the design. The use of weep holes is not recommended due to rapid clogging.
- Provide a uniform grade between the inlets and outlets to ensure that all water is discharged in 96 hours or less. Routine inspection and maintenance are crucial to ensuring the grade remains as designed.
- Avoid the use of electric pumps. They are subject to failure and often require permanent-water sumps. Structures that do not require pumping should be favored over those that have this requirement.
- Avoid the use of loose rock rip-rap that may hold standing water.
- Design distribution pumping and containment basins with adequate slopes to drain fully. The design slope should take into consideration buildup of sediment between maintenance periods.

Stormwater Structures with Permanent-Water Sumps or Basins (Belowground)

- Where possible, seal access holes (e.g., pickholes in manhole covers) to belowground structures designed to retain water in sumps or basins to minimize

entry of adult mosquitoes. If using covers or screens, maximum allowable gaps of 1/16 inch (2 mm) will exclude entry of adult mosquitoes. Inspect barriers frequently and replace when needed.

- If the sump or basin is completely sealed against mosquitoes, with the exception of the inlet and outlet, the inlet and outlet should be completely submerged to reduce the available surface area of water for mosquitoes to lay eggs (female mosquitoes can fly through pipes).
- Where possible, design belowground sumps with the equipment necessary to allow for easy dewatering of the unit.
- Contact the local mosquito control program for advice with problem systems.

Stormwater Treatment Ponds and Constructed Treatment Wetlands

- Whenever possible, stock stormwater ponds and constructed wetlands with mosquito-eating fish available from local mosquito control programs.
- Design and maintain accessible shorelines to allow for periodic maintenance and/or control of emergent and shoreline vegetation, and routine monitoring and control of mosquitoes. Emergent plant density should be routinely managed so mosquito predators can move throughout the vegetated areas and are not excluded from pond edges.
- Whenever possible, design and maintain deep zones in excess of four feet (1.2 m) to limit the spread of invasive emergent vegetation such as cattails. The edges below the water surface should be as steep as practicable and uniform to discourage dense plant growth that may provide immature mosquitoes with refuge from predators and increased nutrient availability.
- Use concrete or liners in shallow areas to discourage plant growth where vegetation is not necessary.
- Whenever possible, provide a means for easy dewatering if needed.
- Manage the spread and density of floating and submerged vegetation that encourages mosquito production (i.e., water hyacinth, water primrose, parrot's feather, duckweed, and filamentous algal mats).
- If possible, compartmentalize managed treatment wetlands so the maximum width of ponds does not exceed two times the effective distance (40 feet [12 m]) of land-based application technologies for mosquito control agents.

General Access Requirements for Stormwater Treatment Structures

- All structures should be easily and safely accessible, without the need for special requirements (e.g., Occupational Safety and Health Administration - OSHA - requirements for "confined space"). This will allow for monitoring and, if necessary, abatement of mosquitoes.
- If utilizing covers, the design should include spring-loaded or lightweight access hatches that can be easily opened.
- Provide all-weather road access (with provisions for turning a full-size work vehicle) along at least one side of large aboveground structures that are less

than seven meters wide, or both sides if shore-to-shore distance is greater than seven meters. *Note:* Mosquito larvicides are applied with hand held equipment at small sites and with backpack or truck mounted high-pressure sprayers at large sites. The effective swath width of most backpack or truck-mounted larvicide sprayers is approximately 20-25 feet (6-7meters) on a windless day.
- Build access roads as close to the shoreline as possible to allow for maintenance and vector control crews to periodically maintain, control and remove emergent vegetation and conduct routine mosquito monitoring and abatement. Remove vegetation and/or other obstacles between the access road and the structure that might obstruct the path of larvicides to the water.
- Control vegetation (by removal, thinning, or mowing) periodically to prevent barriers to access.

Mosquito Control BMPs for Right of Ways and Easements

Right of ways and easements for a variety of infrastructure exist throughout California. Roadways, power lines, pipelines, canals, bike paths, utility access, railroads, etc. have lands associated with them that may produce mosquitoes. It is the responsibility of the company or individual associated with the infrastructure to prevent a public nuisance arising from the property, including a mosquito problem. The lands are as varied as the terrain in California, but the mosquito breeding sites found on these properties will be similar to those found in other sections of this manual.

Inspection of Property and Identification of Mosquito Sources

- Inspect property for standing water or evidence of standing water that may become mosquito sources.

Review and Implement Mosquito Control BMPs as Appropriate

Some rights of way and easements are very long and may have multiple types of mosquito breeding sites that fall within every category listed below, others will have none. After inspecting the property, implement mosquito control BMPs found in the sections below.

- If the property is in an urban area and is managed as commercial property, please refer to the following section:
  - *Residential and landscaped properties*, see page 5.

- If the property is associated with an irrigation canal or similar rural water conveyance, please refer to the following sections:
  - *Rural properties*, see page 6.
  - *Wetlands*, see page 9.

- If the property is associated with a variety of habitats like a railroad or pipeline

right of way, please refer to the following sections:
  - *Rural* properties, see page 6.
  - *Wetlands*, see page 9.

- If the property is associated with a roadway or other structure that would require management of runoff water, please refer to the following section:
  - *Stormwater management* (associated BMPs), see page 14.

In many instances, right of ways and easements will simply fall to the local mosquito and vector control program or go completely unmanaged because they are very large and it is not possible to determine the responsible party.

Mosquito Control BMPs for Wastewater Treatment Facilities

Wastewater treatment facilities are designed to collect, treat, and release nutrient rich highly organic water. These facilities implement practices appropriate to removing contaminants from wastewater, but which may be in direct conflict with BMPs intended to prevent development of mosquito larvae. Further, managers are under intense pressure to meet water quality standards in effluent water and are frequently concerned that mosquito control BMPs will jeopardize compliance with effluent standards.

Wastewater facilities often include features that can produce mosquitoes. Examples include 1) a series of treatment or evaporation ponds, 2) the use of tules or other emergent vegetation to remove contaminants, 3) aerated and non-aerated ponds with emergent vegetation around the edges or throughout, 4) cracks and openings in crusted waste matter on the surface of treatment ponds, and 5) abandoned or unused pond basins that frequently hold shallow water. Certain activities may also create or enhance mosquito habitat including 1) allowing evaporation of wastewater from treatment ponds for maintenance or as a standard treatment method, 2) release of wastewater into marshes or floodplains for evaporation or infiltration, and 3) distribution of sludge onto irrigated agricultural lands.

For mosquito control around buildings and grounds, consult the *residential and landscape* section of this document. Similarly, many BMPs included in the *wetlands and dairy* sections of this document are pertinent to wastewater management facilities, particularly those sections related to construction and management of treatment ponds and wetlands and the use and distribution of wastewater or sludge onto agricultural lands. For mosquito control related to wastewater collection, conveyance, and distribution consult the *stormwater management* section of this manual.

- Monitor all treatment ponds for mosquito larvae – particularly in areas of emergent vegetation.
- Remove emergent vegetation from edges of aerated ponds.
- Immediately incorporate sludge into soil through plowing or disking.
- Insure all water distributed onto evaporation ponds dries completely in less than 96 hours.

- Check abandoned ponds or tanks weekly to ensure they are completely dry.
- Use mechanical agitation to prevent the formation of any crust on treatment ponds or tanks.
- Work closely with a local vector control program. If there is no local vector control agency, consult the closest vector control program, the local public health officer, or CDPH to prevent or abate a mosquito problem from the facility.

Mosquito Control BMPs for Wildlands – Undeveloped Areas

California encompasses about 100 million acres (40 million hectares) of land. Approximately 75 million acres (30 million hectares) are classified as wildlands, which include all undeveloped and non-cultivated property in the state. In many cases the properties are remote and mosquito control is neither feasible nor warranted. However, if you own a property that is near a town or are aware of a mosquito problem at the property, you may wish to contact the closest vector control program or CDPH to determine what if anything can be done to alleviate the problem.

Mosquito Control BMPs that May be Applicable to Wildlands

- Conduct routine mosquito surveillance by looking for immature mosquitoes in the water. Apply EPA-registered products (typically containing Bti, Bs, or methoprene) to control mosquito larvae.
- Evaluate reports of mosquito annoyance from visitors or the public, and if possible work with a local mosquito control program to be notified if there is an adult mosquito problem on or near your property.
- After a rainfall, pay particular attention to temporary water sources and ponds that rise. Treat sources with mosquito control products if needed.
- Stock ornamental ponds and other water features with mosquitofish available from local mosquito control programs. However, their use is restricted in natural bodies of water or in water features that drain into natural bodies of water. Land managers must consult with the local mosquito control agencies regarding proper use of mosquitofish or other available biological control agents.
  Work closely with a local mosquito control program to accurately identify, map, and monitor areas that may produce mosquitoes; and tailor control measures for each site, contingent on the species of mosquitoes that are present.
- Implement personal protective measures
  - Provide visitors and guests with information regarding the risk of mosquito-borne disease transmission and personal protective measures.
  - Install and maintain tight-fitting window and door screens on buildings.
  - If possible, minimize outdoor activities at dawn and dusk when mosquitoes are the most active.
  - Wear protective clothing such as long-sleeved shirts and long pants when going into mosquito-infested areas.
  - Use mosquito repellent when necessary, carefully following the directions on the label.

Evaluation of the Efficacy of BMPs

Landowners can easily evaluate the efficacy of the mosquito control BMPs they have implemented. You can do a simple evaluation as follows:

- Immature mosquitoes: Look for immature mosquitoes in standing water on your property – if the number is decreasing noticeably or immature mosquitoes can not be found, the BMPs you have implemented are working.
- Adult mosquitoes: Simply be aware of the level of mosquito annoyance you experience and ask guests or employees about their experience with regard to mosquitoes. People become accustomed to a certain level of mosquito activity and commonly notice increases or decreases in that level. If the annoyance level is increasing, you have more work to do; if the number is decreasing or mosquitoes are not noticeable – good job! The BMPs you have implemented are working.

The best way to evaluate the effectiveness of BMPs is through a comprehensive surveillance program of larval dipping and adult mosquito trapping, including species identification. Some important strengths of local mosquito control programs are their ability to evaluate treatment options, estimate treatment costs, recommend and implement those BMPs most appropriate for a property. Local mosquito abatement programs also are familiar with indigenous mosquito species and therefore know the type of habitat those mosquitoes come from, often monitor adult populations, and can identify if there is a mosquito problem in a particular area. Landowners can make substantial progress in solving mosquito problems on their own, but if possible, they should work closely with a local mosquito control program to implement and evaluate mosquito control BMPs.

Vector Control Service Coverage in California
Vector Service Area
Del Norte
Siskiyou
Modoc
Humboldt
Trinity
Shasta
Lassen
Tehama
Plumas
Glenn
Butte
Sierra
Mendocino
Nevada
Colusa
Yuba
Placer
Lake
Sutter
El Dorado
Yolo
Sacramento
Alpine
Sonoma
Napa
Amador
Solano
Calaveras
Marin
San Joaquin
Tuolumne
Contra Costa
Mono
San Francisco
Alameda
Stanislaus
Mariposa
San Mateo
Santa Clara
Merced
Madera
Santa Cruz
Fresno
San Benito
Inyo
Monterey
Kings
Tulare
San Luis Obispo
Kern
Santa Barbara
Ventura
Los Angeles
Orange
Riverside
San Diego
Imperial
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CDPH-VBDS
NAD83 California Teale All
last update: March 2012

Table 1: Mosquito Control Agencies in California

COUNTY	AGENCY	WEBSITE or ADDRESS	TELEPHONE
ALAMEDA	ALAMEDA CO MAD	http://www.mosquitoes.org	(510) 783-7744
ALAMEDA	ALAMEDA CO VCSD	http://www.acvcsd.org	(510) 567-6800
AMADOR	AMADOR CO ENV HEALTH DEPT	http://www.co.amador.ca.us/index.aspx?page=385	(209) 223-6487
BUTTE	BUTTE CO MVCD	http://www.bcmvcd.com/	(530) 533-6038
BUTTE	DURHAM MAD	PO Box 386, Durham, CA 95938	(530) 345-2875
BUTTE	OROVILLE MAD	PO Box 940, Oroville, CA 95965	(530) 534-8383
CALAVERAS	SADDLE CREEK CSD	http://www.saddlecreekcsd.org	(209) 785-0100
COLUSA	COLUSA MAD	PO Box 208, Colusa, CA 95932	(530) 458-4966
CONTRA COSTA	CONTRA COSTA MVCD	http://www.contracostamosquito.com/	(925) 771-6100
EL DORADO	CO OF EL DORADO CO ENV. MGT. DEPT.	http://www.edcgov.us/VectorControl/	(530) 573-3450
FRESNO	COALINGA-HURON MAD	P. O. Box 278, Coalinga, CA 93210	(559) 935-1907
FRESNO	FRESNO MVCD	http://www.fresnomosquito.org	(559) 268-6565
FRESNO	FRESNO WESTSIDE MAD	PO Box 125, Firebaugh, CA 93622	(559) 659-2437
FRESNO / KINGS	CONSOLIDATED MAD	http://www.mosquitobuzz.net	(559) 896-1085
GLENN	GLENN CO MVCD	165 County Rd. G, Willows, CA 95988	(530) 934-4025
IMPERIAL	IMPERIAL CO VCP	http://www.icphd.org/sub.php?menu_id=307	(760) 336-8530
INYO	INYO COUNTY DEPT OF AG OWENS VALLEY MAP	http://www.inyomonoagriculture.com/ovmap.html	(760) 873-7853
KERN	DELANO MAD	PO Box 220, Delano, CA 93216	(661) 725-3114
KERN	KERN MVCD	4705 Allen Road, Bakersfield, CA 93314	(661) 589-2744
KERN	SOUTH FORK MAD	P. O. Box 750, Kernville, CA 93238	(760) 376-4268

COUNTY	AGENCY	WEBSITE or ADDRESS	TELEPHONE
KERN	WEST SIDE MVCD	PO Box 205, Taft, CA 93268	(661) 763-3510
KINGS	KINGS MAD	PO Box 907, Hanford, CA 93232	(559) 584-3326
LAKE	LAKE CO VCD	http://www.lcvcd.org	(707) 263-4770
LOS ANGELES	ANTELOPE VALLEY MVCD	http://www.avmosquito.org	(661) 942-2917
LOS ANGELES	COMPTON CREEK MAD	1224 S. Santa Fe Avenue, Compton, CA 90221	(310) 933-5321
LOS ANGELES	GREATER LOS ANGELES CO VCD	http://glacvcd.org	(562) 758-6501
LOS ANGELES	LONG BEACH CITY DHHS	http://www.longbeach.gov/health/eh/vector/	(562) 570-4170
LOS ANGELES	LOS ANGELES CO DHS, VMP	http://www.lapublichealth.org/eh/SSE/Vector_Management/vecman.htm	(626) 430-5450
LOS ANGELES	LOS ANGELES CO WEST VCD	http://www.lawestvector.org	(310) 915-7370
LOS ANGELES	PASADENA CITY HD	http://www.cityofpasadena.net/publichealth/environmental_health_sevices/	(626) 744-6062
LOS ANGELES	SAN GABRIEL VALLEY MVCD	http://www.sgvmosquito.org	(626) 814-9466
MADERA	MADERA CO MVCD	http://maderamosq.org/	(559) 674-6729
MARIN / SONOMA	MARIN / SONOMA MVCD	http://www.msmosquito.com/	(707) 285-2204
MERCED	MERCED CO MAD	http://mcmosquito.org/	(209) 722-1527
MODOC	CA PINES CSD	HCR Box 43002, Alturas, CA 96101	(530) 233-2766
MODOC	CITY OF ALTURAS	http://www.cityofalturas.org	(530) 223-2377
MONO	JUNE LAKE PUD	P. O. Box 99, June Lake, CA 93529	(760) 648-7778
MONO	MAMMOTH LAKES MAD	PO Box 1943, Mammoth Lakes, CA 93546	(760) 924-8240
MONTEREY	NORTHERN SALINAS VALLEY MAD	http://www.montereycountymosquito.com/Site/Welcome.html	(831) 422-6438
NAPA	NAPA CO MAD	http://www.napamosquito.org	(707) 553-9610
NEVADA	NEVADA COUNTY COMMUNITY DEVELOPMENT AGENCY	http://www.mynevadacounty.com/nc/cda/eh/Pages/West-Nile-virus-Information.aspx	(530) 265-1500
ORANGE	ORANGE CO VCD	http://www.ocvcd.org	(714) 740-4150

COUNTY	AGENCY	WEBSITE or ADDRESS	TELEPHONE
PLACER	PLACER MVCD	http://www.placermosquito.org	(916) 380-5444
RIVERSIDE	BLYTHE CITY PWD	http://www.cityofblythe.ca.gov/index.aspx?NID=108	(760) 922-6611
RIVERSIDE	COACHELLA VALLEY MVCD	http://www.cvmvcd.org	(760) 342-8287
RIVERSIDE	NORTHWEST MVCD	http://www.northwestmosquitovector.org/Northwest_MVCD/Home.html	(951) 340-9792
RIVERSIDE	RIVERSIDE CITY PWD	http://www.riversideca.gov/pworks/vector-control.asp	(909) 351-6127
RIVERSIDE	RIVERSIDE CO DEH, VCP	http://www.rivcoeh.org/opencms/rivcoeh/ProgServices/Food_Program/Vector.html	(909) 358-5172
SACRAMENTO / YOLO	SACRAMENTO-YOLO MVCD	http://www.fightthebite.net	(916) 685-1022
SAN BERNARDINO	SAN BERNARDINO CO VCP	http://www.sbcounty.gov/ehlus/Depts/VectorControl/mosquito_and_vector_control_home.aspx	(909) 387-4688
SAN BERNARDINO	WEST VALLEY MVCD	http://www.wvmosquito.org	(909) 635-0307
SAN DIEGO	SAN DIEGO CO DEH, VSC	http://www.sdcounty.ca.gov/deh/pests/vector_disease.html	(858) 694-2888
SAN FRANCISCO	SAN FRANCISCO DPH	http://www.sfdph.org/dph/EH/Vector/default.asp	(415) 252-3988
SAN JOAQUIN	SAN JOAQUIN CO MVCD	http://sjmosquito.org	(209) 982-4675
SAN MATEO	SAN MATEO CO MVCD	http://www.smcmad.org	(650) 344-8592
SAN MATEO	SOUTH BAYSIDE SYSTEM AUTHORITY	http://www.sbsa.org/	(650) 594-8411
SANTA BARBARA	SANTA BARBARA COASTAL VCD	http://www.sbcvcd.org	(805) 969-5050
SANTA CLARA	SANTA CLARA CO VCD	http://www.sccgov.org/portal/site/vector	(408) 918-4770
SANTA CRUZ	SANTA CRUZ CO MVCD	http://www.agdept.com/mvc.html	(831) 454-2590
SHASTA	BURNEY BASIN MAD	PO Box 1049, Burney, CA 96013	(530) 335-2133
SHASTA	PINE GROVE MAD	PO Box 328, MacArthur, CA 96056	(530) 336-5740
SHASTA	SHASTA MVCD	http://www.shastamosquito.org/	(530) 365-3768
SOLANO	SOLANO CO MAD	http://www.solanomosquito.com	(707) 437-1116

COUNTY	AGENCY	WEBSITE or ADDRESS	TELEPHONE
STANISLAUS	EAST SIDE MAD	http://www.eastsidemosquito.com	(209) 522-4098
STANISLAUS	TURLOCK MAD	http://mosquitoturlock.com	(209) 634-8331
STATEWIDE	CALIFORNIA DEPARTMENT OF PUBLIC HEALTH VECTOR-BORNE DISEASE SECTION	http://www.westnile.ca.gov/	(916) 552-9730
SUTTER / YUBA	SUTTER-YUBA MVCD	http://www.sutter-yubamvcd.org/	(530) 674-5456
TEHEMA	TEHAMA CO MVCD	PO Box 1005, Red Bluff, CA 96080	(530) 527-1676
TULARE	DELTA VCD	http://www.deltavcd.com	(559) 732-8606
TULARE	TULARE MAD	6575 Dale Fry Road, Tulare, CA 93274	(559) 686-6628
VENTURA	MOORPARK CITY VCD	http://ci.moorpark.ca.us/cgi-bin/htmlos.exe/03565.1.14766059450000012944	(805) 517-6248
VENTURA	VENTURA CO EHD	http://www.ventura.org/rma/envhealth/technical-services/vector/index.html	(805) 654-2818

Appendix A
Mosquito Control and Arbovirus Surveillance

Mosquito Control Practices

Mosquito control agencies and private landowners in California work cooperatively to implement an integrated pest management (IPM) approach to mosquito control. Source reduction (eliminating the places where mosquito larvae hatch and develop) is the most effective way of preventing adult mosquitoes; however, it may be possible to eliminate mosquito production from a source through other modifications of habitat and/or water management. Biological control agents, including native or introduced predators, are often utilized in combination with water management practices. Pesticides are an important part of an IPM program and mosquito specific larval control pesticides are often used to supplement other source reduction activities. When source reduction and larval control have not adequately reduced the mosquito population, the application of pesticides to control adult mosquitoes may be necessary. Personnel working for vector control agencies who apply pesticides in California are certified by California Department of Public Health (CDPH) after demonstrating the knowledge necessary to control mosquitoes safely and effectively using IPM techniques.

Larval Control

Larval control is the foundation of most mosquito control programs in California. Whereas adult mosquitoes are widespread in the environment, larvae must have water to develop; control efforts therefore can be focused on aquatic habitats. Minimizing the number of adults that emerge is crucial to reducing the incidence and risk of disease. The three key components of larval control are environmental management, biological control, and chemical control.

Environmental Management

Manipulating or eliminating potential mosquito breeding sources can provide dramatic reductions in mosquito populations. There are three levels of environmental management.

1. Source elimination: This approach completely eliminates potential habitats for mosquitoes. This strategy is generally limited to artificial habitats created by urbanization. Examples of source elimination include emptying or turning over containers holding water, filling in holes containing water with sand or gravel, cleaning drainage ditches of debris, and covering or inverting structures and vessels that could hold water.

2. Source reduction: This strategy aims to alter and sometimes eliminate available habitat for larvae which substantially reduces mosquito breeding and the need for

repeatedly applying pesticides. Unlike source elimination, standing water may exist but the total amount of water, or the time the water is left standing, is greatly reduced. Source reduction may require some maintenance (see below) to prevent further mosquito breeding. Examples of source reduction include limiting the growth of emergent vegetation in wetlands and ponds, constructing drainage ditches to remove water from areas prone to flooding, and clearing stormwater channels of silt and debris. Routine larval monitoring can indicate whether these efforts are effective or need further action.

3. Source maintenance: When eliminating or significantly altering mosquito breeding sources is prohibited and/or inappropriate, reducing the number of sheltered, predator-free habitats while having minimal impact on the surrounding environment can make an area unsuitable for mosquitoes. Source maintenance can include water management, vegetation management, wetland infrastructure maintenance, and wetland restoration. Strategic, focused plans must be developed for each site.

Biological Control

Biological control uses predators, parasites, or pathogens to reduce populations of mosquito larvae and is often combined with environmental management to enhance results. The mosquitofish (*Gambusia affinis)* has been used to control mosquitoes in California since 1921 and is the most widely used biological control agent in the world. These small fish are effective against mosquito larvae because they grow and reproduce rapidly, feed at the water surface where mosquito larvae are found, and tolerate a wide range of temperature and water quality.

Other fish are occasionally used with mixed success. Fish are most effective in permanent ponds and wetlands, but are also used in rice fields and stormwater canals with permanent water. Many local mosquito control agencies propagate mosquito-eating fish.

Although many other animals have been tested for mosquito control, and in natural wetlands predation is an important factor in reducing mosquito production, biological control by the intentional addition of mosquito predators other than mosquitofish is largely experimental rather than operational.

Chemical Control

Pesticides that control mosquito larvae are called larvicides. Four types of larvicides (bio-rational, surface films, growth regulators, and chemical products) encompassing seven active ingredients are registered for use in California. Larvicides are applied by hand, from hand-held or vehicle-mounted engine-driven blowers, or by aircraft, depending on the product, the formulation, and the target habitat. Applicators of any of these products must be certified by the CDPH or an appropriate regulatory authority.

1. Bio-rational products

Bio-rational products exploit insecticidal toxins found in certain naturally occurring bacteria. These bacteria are cultured in mass and packaged in various formulations. The bacteria must be ingested by mosquito larvae so the toxin is released. Therefore bio-rational products are only effective against larvae since pupae do not feed. The bacteria used to control mosquito larvae have no significant effects on non-target organisms when applied for mosquito control in accordance with product labels.

Two products that are used against mosquito larvae singly or in combination are *Bacillus thuringiensis israelensis* (Bti) and *Bacillus sphaericus* (Bs). Manufactured Bti contains dead bacteria and remains effective in the water for 24 to 48 hours; some slow release formulations provide longer control. In contrast, Bs products contain spores that in favorable conditions remain effective for more than 30 days. Both products are safe enough to be used in water that is consumed by humans.

Another bio-rational product available for mosquito control is derived from the soil bacterium *Saccharopolyspora spinosa,* which produces natural metabolites called spinosyns during fermentation. These metabolites are lethal to mosquito larvae when ingested or by contact. The most active metabolites are formulated into a product called “spinosad”. The product affects the central nervous system of the mosquito causing uncontrolled nervous impulses, ultimately killing the larvae.

2. Surface agents

Mosquito larvae and pupae breathe through tubes called “siphons” that extend above the water surface. Surface agents such as highly refined mineral oils or monomolecular films (alcohol derivatives) can spread across the surface of the water to prevent mosquitoes from breathing. Depending on the product, the film may remain on the water’s surface from a few hours to a few days. Surface films are the only available products that are effective against very late stage larvae and pupae.

3. Insect growth regulators

Insect growth regulators (IGRs) disrupt the physiological development of larvae thus preventing adults from emerging. The two products currently used for controlling mosquito larvae are methoprene and diflubenzuron.

The effective life of these products varies with the formulation. Methoprene can be applied in granular, liquid, pellet, or briquette formulation. Methoprene has minimal non-target effects and no use restrictions. Diflubenzuron is rarely used in California because it may affect growth of non-target aquatic invertebrates. IGRs for mosquito control can be used in sources of water that are consumed by humans.

4. Chemical larvicides

Chemical pesticides are rarely used to control mosquito larvae. Organophosphate larvicides are used infrequently because of their potential non-target effects and label restrictions. The organophosphate pesticides temephos and malathion are registered for use as larvicides in California. However, malathion is currently used exclusively for adult mosquito control in the state. Temephos can be safely and effectively used to treat temporary water or highly polluted water where there are few non-target organisms and/or livestock are not allowed access. The efficacy of temephos may be up to 30 days depending on the formulation.

Adult Control

IPM mosquito control programs initiate adult mosquito control when action levels or thresholds are reached or exceeded. Thresholds are based on local sampling of the adult mosquito population and/or when the risk of mosquito-borne disease increases above levels established by a local agency, often following guidelines established in the California Mosquito-borne Virus Surveillance and Response Plan. Thresholds are an integral component of mosquito control because they provide a range of predetermined actions based on quantified data. Thresholds also establish expectations and boundaries for responses that ensure appropriate mosquito control activities are implemented at the appropriate time. The threshold for adult mosquito control depends on several factors including:

- How local citizens tolerate nuisance mosquitoes by evaluating public service requests.
- Overall mosquito abundance.
- Presence of mosquito-borne disease in the region.
- Abundance of mosquito species that are vectors of disease.
- Local acceptance of adult mosquito control activities.
- Climate data.

Adult mosquitoes can only be controlled with adulticides. Many mosquito control programs in California include adulticiding as an integral component of their IPM program. Adulticiding falls into two categories – barrier applications and ultra-low volume (ULV) applications. Barrier applications target resting mosquitoes by applying pesticides to vegetation and structures. Barrier applications typically cover relatively small areas and are applied to alleviate specific problems rather than an area wide adult mosquito problem.

ULV applications are used to control adult mosquitoes over large areas. An “ultra-low volume” (typically less than 2 oz / acre [140 ml / ha] total volume) of tiny oil or water droplets carrying an insecticide are emitted from specialized equipment mounted to trucks or aircraft. The droplets kill adult mosquitoes on contact. ULV applications are made after sunset or before sunrise to coincide with the time that mosquitoes are most

active, when non-target insects are least active, and when temperature inversions are most likely to occur. These applications are employed when mosquito populations must be reduced immediately to halt disease transmission. Multiple applications in a particular area may be utilized when the objective is to kill a high enough proportion of older adult mosquitoes to break a disease transmission cycle.

Adverse effects from ULV applications are rare; however, people with health problems should be aware when and where the applications are being conducted. This information can be obtained by contacting the local vector control agency. Chemicals currently registered for ULV applications against mosquitoes in California (as of June, 2010) include organophosphates (e.g., malathion and naled), pyrethrins, (e.g., pyrethrum) and pyrethroids (e.g., resmethrin, sumithrin, permethrin, and etofenprox). With the exception of the active ingredient etofenprox, formulations of both pyrethrins and pyrethroids include the synergist piperonyl butoxide (PBO), which increases their activity against mosquitoes.

1. Organophosphates

   Malathion and naled are neurotoxins that act by blocking the enzyme cholinesterase, inhibiting neurologic transmission. Malathion or naled may be used as rotational products with pyrethroid insecticides to help prevent development of pesticide resistance.

2. Pyrethrins

   Pyrethrins and pyrethroids are neurotoxins that act by causing uncontrolled firing of neurons. Pyrethrum is a natural insecticide derived from chrysanthemum flowers. Adult mosquitoes are rapidly paralyzed and killed on contact. Pyrethrins are degraded rapidly by sunlight and chemical processes. Residual pyrethrins from ULV applications typically remain less than one day on plants, soil, and water.

3. Pyrethroids

   Pyrethroids are manufactured pyrethrins. They have very low toxicity to birds and mammals but are toxic to fish if misapplied.

Compounds currently approved for larval and adult mosquito control in California are listed in Appendix B.

Mosquito Surveillance

Mosquito and Mosquito-Borne Disease Monitoring

Monitoring mosquito populations and mosquito-borne disease levels provides the necessary data to make informed management decisions.

The application of any pesticide to control mosquitoes in an IPM program is done after establishing the need to do so through mosquito population monitoring (surveillance).

Larval mosquito surveillance is the process of identifying and checking likely larval developmental sites for immature mosquitoes and treating the water to kill the mosquitoes prior to them emerging as flying, biting adults.

Adult mosquito surveillance is accomplished through a network of traps and through mosquito annoyance reports. Adult mosquito surveillance is a critical component of determining where mosquitoes are coming from, the potential for disease transmission in an area, and the need for adult mosquito control. Districts also use adult surveillance as a feedback or quality control mechanism to determine how effective the overall program is in reducing mosquito populations. Trapping adult mosquitoes and submitting those mosquitoes to test for diseases is often one component of a mosquito-vectored disease surveillance program. Collecting baseline data on mosquito populations and mosquito-borne disease also helps target educational efforts.

Mosquito Surveillance Techniques

1. Larval surveillance

   Larval surveillance is the routine sampling of aquatic habitats for developing mosquitoes. The primary tool is the “dip count” which indicates whether a habitat is producing mosquitoes and estimates larval density. A one-pint cup attached to a long handle is used to collect a standard volume of water (“dip sample”). The “dip count” may be expressed as the number of immature (larvae and pupae) mosquitoes per dip, per unit volume, or per unit surface area of the site.

2. Adult surveillance

   Several types of traps are used for adult surveillance, because mosquitoes are attracted to different traps depending on their species, sex, and physiological condition. The most common traps use light, carbon dioxide, water for egg laying, and a resting area. Trapped adults provide information about local distribution,

density, and identity. The size of an adult mosquito population can also be assessed by the number and distribution of service requests from the public. Data are used to help locate new sources of mosquitoes or known sources with a recurrent problem

Annoyance Biting

Many species of mosquitoes are not important as vectors of disease, but can cause serious injury and discomfort to humans and animals. Each time a female mosquito pierces the skin to take blood, she contaminates the wound with her saliva, creating the potential for a mild allergic reaction. The common symptom of mosquito bites is irritated and swollen skin surrounding the bite with persistent itching for several days. Scratching these bites to alleviate the itching can result in secondary bacterial infections. In addition, when mosquito populations explode, the sheer number of mosquitoes attempting to bite can make life miserable.

Mosquitoes as Disease Vectors

Mosquitoes are the most important insect vectors of disease worldwide, causing millions of human deaths every year. Mosquito-borne pathogens are typically transmitted or "vectored" when a mosquito ingests a disease causing organism, the organism reproduces inside the mosquito, and is subsequently injected along with saliva into another animal or human host. The potential or "competence" to vector any particular disease causing organism varies greatly among mosquito species.

California has a long history of mosquito-borne disease. Mosquito control programs were first developed in the early 1900s to combat malaria and other diseases, and to reduce populations of nuisance mosquitoes. Currently, there are 12 mosquito-borne viruses recognized in California; however, only West Nile virus (WNV), western equine encephalomyelitis (WEE), and Saint Louis encephalitis (SLE) are significant threats to public health. Global trade and travel will continue to provide an avenue for introducing or re-introducing other mosquito-borne pathogens and their vectors into California and the United States. The diseases of greatest concern include Japanese encephalitis, dengue, yellow fever, Rift Valley fever, chikungunya, Venezuelan encephalitis, and malaria.

Virus Surveillance

In 2000, CDPH collaborated with the University of California, Davis, the California Department of Food and Agriculture, local mosquito and vector control agencies, and other state and local agencies to develop a comprehensive statewide surveillance program to detect and monitor WNV activity. More than 70 local mosquito and vector control districts and agencies, environmental health agencies, and county public health departments throughout California routinely contribute to the program. Surveillance includes testing for WNV infections in humans, horses, mosquitoes, wild birds, and "sentinel" chicken flocks located throughout California. The program also includes

testing dead birds reported by the public for infections with WNV. A special website (http://www.westnile.ca.gov/) and toll-free hotline (877-WNV-BIRD) were created and are maintained by CDPH to support this surveillance program. The information from the program allows CDPH and local agencies to identify conditions conducive to WNV transmission and areas with elevated risk. This information is used by local mosquito control agencies to reduce the threat of WNV transmission to humans.

Mosquito Transmitted Diseases

Landowners throughout California, mosquito and vector control agencies, health departments, and CDPH work together to protect Californians from mosquito-borne diseases. Work to minimize the risk of disease transmission includes 1) comprehensive mosquito surveillance and control efforts on private and public lands, 2) agencies providing technical guidance and information to the medical and veterinary communities, and 3) educating the public about mosquitoes, the diseases they carry, and personal protective measures.

Encephalitis

Several mosquito-borne viruses that occur in California can cause encephalitis. The majority of human infections with these viruses have no symptoms. Those with so-called mild symptoms can still have significant illness and face prolonged recovery, and severe cases can be fatal or cause permanent neurological damage. There are several species of mosquitoes in California that can transmit WNV, SLE, and WEE viruses to people and animals. The most important species belong to the genus *Culex*. Specifically *Cx. tarsalis*, *Cx. pipiens*, and *Cx. quinquefasciatus* are significant public health concerns because of their widespread distribution throughout the state, their proximity to humans, and their capacity as very efficient vectors.

West Nile Virus

West Nile virus has become an endemic disease in California and like other encephalitic viruses, can cause serious illness. Many people who are infected do not get sick or may have a variety of symptoms that can include fever, head and body aches, nausea, vomiting, swollen lymph glands, and skin rash. Only about one in 150 infected people will develop a serious illness that may require hospitalization. Elderly people are at highest risk of developing the severe form of WNV and are at an increased risk of long-lasting physical and mental disorders. The severe form of the disease can be fatal.

Malaria

Malaria is caused by four species of protozoa. The parasites destroy red blood cells causing severe fever and anemia. Left untreated, malaria can cause kidney failure, coma, and death. Malaria was once a common public health threat in California and

much of the southern United States, but it was eradicated by intensive mosquito control efforts and the discovery of anti-malarial drugs. However, the disease still occurs in many other countries worldwide, creating a perpetual risk of re-introduction, especially from infected travelers and immigrants. The *Anopheles* mosquitoes capable of transmitting malaria still occur in many areas of California.

Canine Heartworm

Canine heartworm occurs worldwide. It is caused by a filarial nematode transmitted by *Aedes* and some *Culex* mosquitoes that can infect domestic dogs, wild canines (e.g., foxes, coyotes, wolves), and cats. The tiny worms migrate through the body to the heart and cause thickening and inflammation of the heart, which can lead to difficulty in breathing, chronic cough, vomiting, and can sometimes be fatal.

Appendix B
Compounds Approved for Mosquito Control in California

Pesticides used for mosquito control have been evaluated for this purpose by the U.S. Environmental Protection Agency (EPA) and found to pose minimal risks to human health and the environment when used according to label directions. For updated information on specific products approved for use in California, please refer to the California Department of Pesticide Regulation website: http://www.cdpr.ca.gov/docs/label/labelque.htm.

Mosquito and vector control programs that apply pesticides to a water of the United States for the purpose of controlling any vector are required to obtain a National Pollution Discharge Elimination System (NPDES) Permit for Biological and Residual Pesticide Discharges to Waters of the United States. More information on the permit, issued by the State Water Resources Control Board, can be found at: http://www.waterboards.ca.gov/water_issues/programs/npdes/aquatic.shtml#davcp.

The components of this appendix have been adapted from the California Mosquito-Borne Virus Surveillance and Response Plan; please refer to the following website for more information: http://www.westnile.ca.gov.

The use of pesticides to control mosquitoes should be the last resort after BMPs outlined in this manual have been implemented. Individuals considering applying a pesticide must be adequately trained and always apply pesticides according to label directions. In California, local mosquito control agency employees must pass a testing and certification process through CDPH before they can apply pesticides to control mosquitoes. Similarly, commercial pesticide applicators must be appropriately certified by the California Department of Pesticide Regulation. Private landowners applying general use pesticides to control mosquitoes solely on their own property are not required to be certified; however, landowners have the same legal responsibility with regard to pesticide and environment related laws. Private citizens considering using pesticides should consult their County Agricultural Commissioner and the California Department of Fish and Game before application.

Examples of products containing specific active ingredients are provided below, but this is not an inclusive list nor constitutes product endorsement. For more information on pesticides and mosquito control, please refer to the U.S. EPA website: http://www.epa.gov/pesticides/health/mosquitoes/mosquito.htm.

Larvicides

1. *Bacillus thuringiensis*, subspecies *israelensis* (Bti: e.g., Aquabac 200G, VectoBac® 12AS, Teknar HP-D)
   Use: Approved for most permanent and temporary bodies of water.

Limitations: Only works on actively feeding stages. Does not persist well in the water column.

2. *Bacillus sphaericus* (Bs: e.g., VectoLex® CG)
   Use: Approved for most permanent and temporary bodies of water.
   Limitations: Only works on actively feeding stages. Does not work well on all species. May persist and have residual activity in some sites.

3. Spinosad (bacteria derived natural insecticide: e.g., Natular G)
   Use: Approved for most permanent and temporary bodies of water.
   Limitations: Only works on mosquito larvae.

4. IGRs (Insect Growth Regulators)
   a. (S)-Methoprene (e.g., Altosid® Pellets)
   Use: Approved for most permanent and temporary bodies of water.
   Limitations: Works best on older instars. Some populations of mosquitoes may show some resistance.
   b. Diflurobenzuron (e.g., Dimilin®25W)
   Use: Impounded tail water, sewage effluent, urban drains and catch basins.
   Limitations: Cannot be applied to wetlands, crops, or near estuaries.

5. Larviciding oils (e.g., GB-1111, BVA 2 Mosquito Larvicide Oil)
   Use: Ditches, dairy lagoons, floodwater. Effective against all stages, including pupae.
   Limitations: Consult with the California Department of Fish and Game for local restrictions.

6. Monomolecular films (e.g., Agnique® MMF)
   Use: Most standing water including certain crops.
   Limitations: Does not work well in areas with unidirectional winds in excess of 10 mph.

7. Organophosphate compounds
   Temephos (e.g., Abate® 2-BG)
   Use: Non-potable water; marshes; polluted water sites
   Limitations: Cannot be applied to crops for food, forage, or pasture. This material may not be effective on some *Culex tarsalis* populations in the Central Valley.

Adulticides

1. Organophosphate compounds
   Note: Many *Culex tarsalis* populations in the Central Valley have shown resistance to OP pesticides at approved label rates.
   a. Malathion (e.g., Fyfanon® ULV)
      Use: May be applied by air or ground equipment over urban areas, some

crops including rice, wetlands.
Limitations: Paint damage to cars; toxic to fish, wildlife and bees; crop residue limitations restrict application before harvest.

b. Naled (e.g., Dibrom® Concentrate, Trumpet® EC)
Use: Air or ground application on fodder crops, swamps, floodwater, residential areas.
Limitations: Similar to malathion.

c. Chlorpyrifos (e.g., Mosquitomaster 412)
Use: Air or ground application in urban or recreational areas
Limitations: Not registered for use over agricultural commodities or grazing lands and may be toxic to bees, fish, and some wildlife.

2. Pyrethrins (natural pyrethrin products: e.g., Pyrenone® Crop Spray, Pyrenone® 25-5, Evergreen®)
Use: Wetlands, floodwater, residential areas, some crops.
Limitations: Do not apply to drinking water, milking areas; may be toxic to bees, fish, and some wildlife. Some formulations with synergists have greater limitations.

3. Pyrethroids (synthetic pyrethrin products containing deltamethrin, cyfluthrin, permethrin, resmethrin, sumithrin, or etofenprox: e.g., Suspend® SC, Tempo Ultra SC, Aqua-Reslin®, Scourge® Insecticide, Anvil® 10+10 ULV, and Duet, which also contains the mosquito exciter prallethrin)
Use: All non-crop areas including wetlands and floodwater.
Limitations: May be toxic to bees, fish, and some wildlife; avoid treating food crops, drinking water or milk production.

PESTICIDES USED FOR LARVAL MOSQUITO CONTROL IN CALIFORNIA

LARVICIDES

For updated information on specific products approved for use in California, please refer to the California **Department of Pesticide Regulation website: http://www.cdpr.ca.gov/docs/label/labelque.htm**

Active Ingredient	Trade name	EPA Reg. No.	MFG	Formulation	Application	Pesticide classification
Bacillus sphaericus, (Bs)	Spheratax SPH (50G) and WSP	84268-2	Adapco	Granule and Water soluble packet	Larvae	Biorational
Bacillus sphaericus, (Bs)	VectoLex CG and WSP	73049-20	Valent BioSciences	Granule and Water soluble packet	Larvae	Biorational
Bacillus sphaericus, (Bs)	VectoLex WDG	73049-57	Valent BioSciences	Water dispersible granule	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Aquabac 200G and Consume MP	62637-3	Becker Microbial	Granule	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Aquabac XT	62637-1	Becker Microbial	Liquid	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Bactimos PT	73049-452	Valent Biosciences	Granule	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Fourstar SBG	85685-1	Fourstar Microbials	Granule	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Summit Bti Briquets	6218-47	Summit Chemical	Briquet	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac 12AS	73049-38	Valent BioSciences	Liquid	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac G and GS	73049-10	Valent BioSciences	Granule	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac Tech. Powder	73049-13	Valent BioSciences	Technical powder	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	VectoBac WDG	73049-56	Valent BioSciences	Technical powder	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Teknar HP-D	73049-404	Valent BioSciences	Liquid	Larvae	Biorational
Bacillus thuringiensis var. *israelensis* (Bti)	Teknar SC	73049-435	Valent BioSciences	Liquid	Larvae	Biorational
Bs and Bti	Vectomax G, CG, WSP	73049-429	Valent BioSciences	Granule and Packet	Larvae	Biorational
Bs and Bti	Fourstar Briquettes	83362-3	Fourstar Microbials	Briquette	Larvae	Biorational
Spinosad	Natular G	8329-80	Clarke	Granule	Larvae	Biorational
Spinosad	Natular 2EC	8329-82	Clarke	Liquid	Larvae	Biorational
Spinosad	Natular G30	8329-83	Clarke	Granule	Larvae	Biorational

Active Ingredient	Trade name	EPA Reg. No.	MFG	Formulation	Application	Pesticide classification
Spinosad	Natular T30	8329-85	Clarke	Tablet	Larvae	Biorational
Spinosad	Natular XRT	8329-84	Clarke	Tablet	Larvae	Biorational
Monomolecular film	Agnique MMF	53263-28	Cognis Corp.	Liquid	Larvae and pupae	Surface film
Monomolecular film	Agnique MMF G	53263-30	Cognis Corp.	Granule	Larvae and pupae	Surface film
Monomolecular film	Agnique MMF GPak 35	53263-30	Cognis Corp.	Water soluble packet	Larvae and Pupae	Surface film
Petroleum oil	BVA 2	70589-1	BVA Oils	Liquid	Larvae and pupae	Surface film
Petroleum oil	BVA Spray 13	55206-2	BVA Oils	Liquid	Larvae and pupae	Surface film
Petroleum oil	GB 1111	8329-72	Clarke	Liquid	Larvae and pupae	Surface film
Petroleum oil	Masterline Kontrol	73748-10	Univar	Liquid	Larvae and pupae	Surface film
Diflubenzuron	Dimilin 25W	400-465	Uniroyal Chemical	Wettable powder	Larvae	IGR
S-Methoprene	Altosid ALL	2724-392	Wellmark-Zoecon	Liquid	Larvae	IGR
S-Methoprene	Altosid Liquid Larvicide Concentrate	2724-446	Wellmark-Zoecon	Liquid concentrate	Larvae	IGR
S-methoprene	Altosid Briquets	2724-375	Wellmark-Zoecon	Briquet	Larvae	IGR
S-methoprene	Altosid Pellets	2724-448	Wellmark-Zoecon	Pellet-type granules	Larvae	IGR
S-methoprene	Altosid SBG	2724-489	Wellmark-Zoecon	Granule	Larvae	IGR
S-methoprene	Altosid XR	2724-421	Wellmark-Zoecon	Briquet	Larvae	IGR
S-methoprene	Altosid XR-G	2724-451	Wellmark-Zoecon	Pellet	Larvae	IGR
S-methoprene	Metalarv S-PT	73049-475	Wellmark-Zoecon	Pellet	Larvae	IGR
Temephos	Abate 2-BG	8329-71	Clarke	Granule	Larvae	OP

Active Ingredient	Trade name	EPA Reg. No.	MFG	Formulation	Application	Pesticide classification
Temephos	AllPro Provect 1G Larvicide	769-723	AllPro	Granule	Larvae	OP
Temephos	AllPro Provect 5G Larvicide	769-722	AllPro	Granule	Larvae	OP
Temephos	5% Skeeter Abate	8329-70	Clarke	Granule	Larvae	OP

PESTICIDES USED FOR ADULT MOSQUITO CONTROL IN CALIFORNIA
ADULTICIDES

For updated information on specific products approved for use in California, please refer to the California Department of Pesticide Regulation website: http://www.cdpr.ca.gov/docs/label/labelque.htm

Active Ingredient	Trade name	EPA Reg. No.	MFG	Formulation	Application	Pesticide classification
Malathion	Fyfanon® ULV	67760-34	Cheminova	Liquid	Adults	OP
Naled	Dibrom Concentrate	5481-480	AMVAC	Liquid	Adults	OP
Naled	TrumpetÔ EC	5481-481	AMVAC	Liquid	Adults	OP
Cyfluthrin	Tempo Ultra SC	432-1363	Bayer	Liquid	Adults	Pyrethroid
Deltamethrin	Suspend® SC	432-763	Bayer	Liquid	Adults	Pyrethroid
Permethrin	Aqua-Kontrol	73748-1	Univar	Liquid	Adults	Pyrethroid
Permethrin	Aqualeur 20-20	769-985	Value Garden Supply	Liquid	Adults	Pyrethroid
Permethrin	Aqua-Reslin®	432-796	Bayer	Liquid	Adults	Pyrethroid
Permethrin	Biomist® 4+4 ULV	8329-35	Clarke	Liquid	Adults	Pyrethroid
Permethrin	Biomist® 4+12 ULV	8329-34	Clarke	Liquid	Adults	Pyrethroid
Permethrin	Evoluer 4-4 ULV	760-982	Value Garden Supply	Liquid	Adults	Pyrethroid
Permethrin	Evoluer 30-30 ULV	760-983	Value Garden Supply	Liquid	Adults	Pyrethroid
Permethrin	Kontrol 2-2	73748-3	Univar	Liquid	Adults	Pyrethroid
Permethrin	Kontrol 4-4	73748-4	Univar	Liquid	Adults	Pyrethroid
Permethrin	Kontrol 30-30	73748-5	Univar	Liquid	Adults	Pyrethroid
Permethrin	Permanone® Ready-To-Use	432-1277	Bayer	Liquid	Adults	Pyrethroid
Permethrin	Permanone 31-66	432-1250	Bayer	Liquid	Adults	Pyrethroid
Permethrin	Perm-X UL 4-4	655-898	Prentiss	Liquid	Adults	Pyrethroid
Pyrethrins	Aquahalt	1021-1803	Clarke	Liquid	Adults	Pyrethroid
Pyrethrins	Evergreen 60-6	1021-1770	MGK	Liquid	Adults	Pyrethroid
Pyrethrins	Pyranone® 25-5	432-1050	Bayer	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrenone® Crop Spray	432-1033	Bayer	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrocide® 7067	1021-1199	Adapco	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrocide® 7453	1021-1803	MGK	Liquid	Adults	Pyrethroid

Active Ingredient	Trade name	EPA Reg. No.	MFG	Formulation	Application	Pesticide classification
Pyrethrins	Pyrocide® 7395	1021-1570	MGK	Liquid	Adults	Pyrethroid
Pyrethrins	Pyrocide® 7396	1021-1569	MGK	Liquid	Adults	Pyrethroid
Pyrethrins	Pyronyl Crop Spray	655-489	Prentiss	Liquid	Adults	Pyrethroid
Pyrethrins	Pyronyl Oil 525	655-471	Prentiss	Liquid	Adults	Pyrethroid
Pyrethrins	Pyronyl Oil 3610A	655-501	Prentiss	Liquid	Adults	Pyrethroid
Resmethrin	Scourge® Insecticide (4%)	432-716	Aventis	Liquid	Adults	Pyrethroid
Resmethrin	Scourge® Insecticide (18%)	432-667	Aventis	Liquid	Adults	Pyrethroid
Sumithrin	Anvil® 2+2 ULV	1021-1687	Clarke	Liquid	Adults	Pyrethroid
Sumithrin	Anvil® 10+10 ULV	1021-1688	Clarke	Liquid	Adults	Pyrethroid
Sumithrin	AquaAnvil®	1021-1807	Clarke	Liquid	Adults	Pyrethroid
Prallethrin Sumithrin	Duet	1021-1795	Clarke	Liquid	Adults	Pyrethroid
Prallethrin Sumithrin	AcuaDuet	1021-2562-8329	Clarke	Liquid	Adults	Pyrethroid
Etofenprox	Zenivex E4 RTU	2724-807	Wellmark, Intl.	Liquid	Adults	Pryethroid
Etofenprox	Zenivex E20	2724-791	Wellmark, Intl.	Liquid	Adults	Pryethroid
Lambda-cyhalothrin	Demand CS	100-1066	Syngenta	Liquid	Adults	Pryethroid

Appendix C
Health and Safety Codes Pertinent to Mosquito Control

In California, mosquito and vector control agencies are regulated by sections of the California Health and Safety (H&S) Code, Food and Agriculture Code, California Code of Regulations, and others. The following components of this appendix have been adapted from the Overview of Mosquito Control Practices in California, California Department of Public Health: http://www.westnile.ca.gov/resources.php

Governing laws and regulations

Many federal and state laws govern the activities of vector control agencies, including the Clean Water Act (CWA), the Endangered Species Act (ESA), and the Federal Insecticide Fungicide and Rodenticide Act (FIFRA). Pesticide application by vector control agencies in California is regulated under FIFRA. FIFRA is administered through the U.S. Environmental Protection Agency, and regulates the registration, labeling, and sales of pesticides in the United States.

The California H&S Code encourages the formation of local mosquito control programs to protect the public health, safety, and welfare (H&S Code Section 2001-b) Website link: http://leginfo.ca.gov/cgi-bin/displaycode?section=hsc&group=01001-02000&file=2000-2007. The legal responsibility of landowners in California to avoid causing a public nuisance, including mosquitoes is implied in the section. The potential consequences of failing to prevent a public nuisance are described in the Code sections listed below.

Under the H&S Code, local vector control agencies have the authority to conduct surveillance for vectors, prevent the occurrence of vectors, and legally abate production of vectors or public nuisance defined as “Any water that is a breeding place for vectors” and “Any activity that supports the development, attraction, or harborage of vectors, or that facilitates the introduction or spread of vectors.”(H&S Code Section 2002(j) and 2040). Vector control agencies also have authority to participate in review, comment, and make recommendations regarding local, state, or federal land use planning and environmental quality processes, documents, permits, licenses, and entitlements for projects and their potential effects with respect to vector production. (H&S Code Section 2041) Website link: http://caselaw.lp.findlaw.com/cacodes/hsc/2040-2055.html

Additionally, agencies have broad authority to influence landowners to reduce or “abate” the source of a vector problem. Actions may include imposing civil penalties of up to $1000 per day plus costs associated with controlling the vector. Agencies have authority to “abate” vector sources on private and publicly owned properties. (H&S Code Sections 2060-2065). Website link: http://caselaw.lp.findlaw.com/cacodes/hsc/2060-2067.html

Mosquito and vector control programs that enter into a cooperative agreement with the California Department of Public Health are exempted from some pesticide related laws under Title 3 of the California Code of Regulations Section 6620. Specifically, these agencies are exempted from "Consent to Apply" (Title 3, California Code of Regulations, Section 6616), "Notice" (Title 3, California Code of Regulations, Section 6618), and the "Protection of Persons, Animals, and Property" (Title 3, California Code of Regulations, Section 6614). Essentially, these provisions obviate the vector control agency from having to notify or get permission from landowners prior to applying a pesticide to their property in the interest of preserving the public health. Website link: http://www.cdpr.ca.gov/docs/legbills/calcode/030201.htm#a6620

A vector control technician working at a vector control agency must be a "certified technician" or work under the direct supervision of a "certified technician" to apply pesticides. Vector control technicians achieve certification through an examination process administered by the California Department of Public Health.

Vector control agencies cannot use any pesticide not registered for use in California, and are required to keep detailed records of each pesticide application, including date, location, and amount applied. All pesticides must be applied in accordance with the labeling of the product as registered with the U.S. EPA.

Appendix D
Mosquitoes of California

The biology and key characteristics of the four major mosquito genera in California are described below.

Aedes

There are about 80 species of *Aedes* mosquitoes in the continental United States; 24 species occur in California. Certain species are widespread, may occur in very large numbers, and are among the worst biting pests. *Aedes* mosquitoes do not lay their eggs directly on the surface of standing water. Instead, they lay single eggs on intermittently flooded surfaces such as the damp soil around irrigated pastures and fields, along the edges of coastal tidal marshes, and inside dry treeholes and containers. Eggs are extremely resistant to drying and will lie dormant on dry surfaces until flooding occurs (eggs of *Ae. vexans* have been documented to lie dormant for up to three years). This can lead to many generations of eggs in a given habitat if female mosquitoes lay successive batches of eggs before the area is flooded. When flooding occurs, large numbers of eggs hatch spontaneously and develop rapidly to adults. Although larval developmental sites vary greatly, the most productive include transient ground pools, flooded areas along overflowing streams, flood and stormwater control basins, intermittently flooded agricultural lands, and container habitats such as tree holes, wheel ruts, and discarded tires.

Aedes are primarily summer-breeding mosquitoes. Because of their rapid larval development in newly-flooded habitats, adults often emerge before predators can colonize the water source. Most *Aedes* complete two to several generations per year depending on the frequency of habitat flooding from natural and artificial events. Adults cannot survive in colder weather. Therefore the majority of *Aedes* overwinter as eggs.

Typically, *Aedes* mosquitoes found in California will not enter buildings and homes; however, they are strong fliers and are known to travel many miles from their aquatic developmental sites to search for hosts. *Aedes* mosquitoes are diurnal (i.e., active during the day) during mild weather, especially around shaded areas, but will also bite at dusk. Most *Aedes* females feed on large mammals like cattle and horses, but will readily feed on humans. *Aedes* mosquitoes are aggressive and persistent biters causing people and animals to avoid areas where their numbers are great. One example is the species *Ae. nigromaculis*, which are currently not known to vector disease, but are considered a serious pest because they will seek out human hosts and bite during the day when people are most likely to be outdoors and active.

Anopheles

Approximately 22 species of *Anopheles* are found in the continental United States and of these, 5 occur in California. When feeding, *Anopheles* adults rest with their abdomens positioned at a distinct angle to the surface of the skin, whereas other species orient their bodies parallel. Females lay single floating eggs directly on the

surface of permanent or semi-permanent standing water. A female can lay successive batches of up to 300 eggs during the breeding season. Eggs are not resistant to drying and typically hatch within two-three days, although hatching may take up to two-three weeks in colder climates. Larvae develop in 12 to 20 days, but can take longer in cooler weather. Preferred larval habitats include clear, fresh seepage water in sunlit or partly shaded pools, wetlands, roadside ditches, rice fields, and poorly maintained water troughs.

Adult females bite at dusk and dawn and prefer to feed on mammals. Many *Anopheles* mosquitoes prefer to feed on rabbits, but will also feed on large mammals such as livestock and humans. In California, *Anopheles* species may undergo two or more generations per year. Most species over-winter in protected areas as mated females, resuming activity the following spring. These are among the first mosquitoes to emerge and bite humans each year.

Historically, *Anopheles freeborni*, the western malaria mosquito, was a vector of malaria in California. Currently, with the disease eradicated from California and the United States, it is considered a nuisance mosquito. This species is widespread throughout California and females will lay their eggs in any standing fresh water, although it is abundant in rice fields or other wetlands during late summer. While most adult mosquitoes stay within a few miles of their breeding source, they will migrate further when seeking hibernation sites in fall. This can lead to a large influx of mosquitoes from uncontrolled areas to residential areas during September and October.

Culex

Culex, with 11 species found throughout the state is the second largest genus of mosquitoes in California, second only to *Aedes*. Females can lay up to seven rafts of eggs over a two-month life span; each raft contains from 100-300 eggs which are laid on the surface of standing water. *Culex* larvae occur in a broad range of aquatic sites ranging from containers such as discarded tires, water barrels, and flower pots to clogged gutters, catch basins, and water for irrigation and urban wastewater. During summer and periods of drought, areas without regularly flowing water, street drainage systems, and contaminated streams, ponds and pools become productive larval habitats. *Culex* larvae are known for thriving in polluted sources of water with a high organic content.

Culex mosquitoes prefer to take blood meals at dusk or after dark and can be painful and persistent biters. *Culex* preferably feed on birds but also feed on mammals including humans and horses. They readily enter houses and buildings in search of a suitable host. Two or more generations of *Culex* can occur per year. Females that emerge in late summer will mate and overwinter until the following spring or mid-summer.

Several species of *Culex* can transmit viruses that can cause encephalitis (i.e., inflammation of the brain), including WNV, SLE, and WEE. These mosquitoes are

efficient and effective vectors of these diseases among birds, humans, horses and many other wild and domestic animals.

Culex tarsalis

Culex tarsalis, the Western encephalitis mosquito, is one of California's most important and efficient vectors of WNV, SLE, and WEE. This species is widespread in California. *Cx. tarsalis* prefer to lay their eggs on fresh or lightly polluted standing water such as rice fields, ditches, pastures, waste water ponds, and seasonal wetlands. Other more urban freshwater sources include ornamental ponds, storm drains, and flood control channels. Larvae usually develop into adults in approximately 8-14 days; warmer water can shorten the developmental period. *Cx. tarsalis* are active from spring through fall; however the population in the Central Valley peaks in June to July with a secondary, smaller peak in September coinciding with flooding of seasonal wetlands. *Cx. tarsalis* survive through the winter as adults in barns, culverts, caves, and similar dark, protected places.

Adult *Cx. tarsalis* can disperse a great distance up to 10-15 miles (16-24 km) in search of blood meals, generally traveling along riparian corridors, but most stay close to the site where they emerged. Adults rest by day in shaded areas such as animal burrows and treeholes. Females prefer feeding between dusk and dawn but may bite during the day in deep shade. Females obtain blood meals from birds or mammals and can transmit diseases between these groups.

Culex pipiens* and *Culex quinquefasciatus

Culex pipiens (the northern house mosquito) and *Culex quinquefasciatus* (the southern house mosquito) appear to be identical. *Cx. quinquefasciatus* occurs in Southern California, whereas *Cx. pipiens* is found along the coastal regions and in Northern California and is the most widely distributed mosquito species in the world. Both species can transmit encephalitis viruses. They are common in and around households and prefer to lay eggs in polluted water that is high in organic content such as dairy runoff, wastewater catchment basins, stormwater ponds, dirty flower pots, bird baths, or any drainage systems where standing water exists.

In California, *Cx. pipiens* and *Cx. quinquefasciatus* typically do not disperse from where they emerged. Females feed at dusk or after dark, readily enter homes and prefer avian hosts but will also feed on large mammals including humans. *Cx. pipiens* and *Cx. quinquefasciatus* are vectors of WNV and SLE virus, and have also been implicated in transmitting canine heartworm.

Other *Culex* mosquitoes.

Culex stigmatosoma, the foul water mosquito, *Cx restuans* and *Cx. erythrothorax* can also be infected with WNV, but their distributions are limited (e.g., *Cx. erythrothorax* is mainly found close to bodies of water with tules).

Culiseta

Only eight species of *Culiseta* mosquitoes occur in the continental United States, of which four are found in California. Females lay clusters of floating eggs (rafts) on the surface of standing water. *Culiseta* mosquitoes are moderately aggressive biters, attacking in the evening hours or in shade during the day. Peak populations occur during the cooler months. These mosquitoes prefer to feed on larger domestic animals, such as cattle and horses, but will also feed on humans. The distribution of *Cs. inornata*, an unusually large mosquito, is widespread and can be found at elevations of up to 10,000 feet. Larvae of *Cs. inornata* develop in permanent water habitats, including shallow marshes, peat bogs, roadside ditches, abandoned gravel pits, and in standing water in soil cavities left by fallen trees. The common name of this mosquito—the Large Winter mosquito—reflects that it is most active in cool weather habitats.

Appendix E
Typical Larval Habitats of California Mosquitoes*

Riparian	Vernal Pools	Foul Water	Salt Marsh	Treehole
Aedes atropalpus	*Aedes bicristatus*	*Culex pipiens*	*Aedes dorsalis*	*Aedes deserticola*
Aedes washinoi	*Aedes campestris*	*Culex restuans*	*Aedes squamiger*	*Aedes purpureipes*
Aedes pullatus	*Aedes fitchii*	*Culex stigmatosoma*	*Aedes taeniorhynchus*	*Aedes sierrensis*
Aedes sticticus	*Aedes hemiteleus*	*Culex tarsalis*	*Anopheles occidentalis*	*Orthopodomyia signifera*
Aedes vexans	*Aedes increpitus*	*Culiseta impatiens*	*Culex tarsalis*	
Anopheles franciscanus	*Aedes niphadopsis*	*Culiseta incidens*	*Culiseta incidens*	
Anopheles occidentalis	*Aedes ventrovittis*	*Culiseta inornata*	*Culiseta inornata*	
Anopheles punctipennis	*Aedes washinoi*			
Culex apicalis	*Culex tarsalis*			
Culex boharti	*Culiseta incidens*			
Culex reevesi	*Culiseta inornata*			
Culex tarsalis	*Psorophora columbiae*			
Culex territans	*Psorophora signipennis*			
Culex thriambus				
Culiseta impatiens				
Culiseta incidens				
Culiseta particeps				
Culiseta inornata				
Small Container	**Freshwater Marsh**	**Rock Pools**	**Pools and Ponds**	**Snow Melt Pools**
Aedes sierrensis	*Aedes flavescens*	*Aedes sierrensis*	*Aedes sierrensis*	*Aedes cataphylla*
Culex pip/quinq	*Anopheles freeborni*	*Anopheles punctipennis*	*Culex pip/quinq*	*Aedes clivis*
Culiseta incidens	*Anopheles hermsi*	*Culex tarsalis*	*Culex stigmatosoma*	*Aedes communis*
	Anopheles occidentalis	*Culiseta impatiens*	*Culex tarsalis*	*Aedes hexodontus*
	Coquillettidia perturbans	*Culiseta incidens*	*Culiseta impatiens*	*Aedes increpitus*
	Culex erythrothorax		*Culiseta incidens*	*Aedes pullatus*
	Culex tarsalis		*Culiseta inornata*	*Aedes schizopinax*
	Uranotaenia anhydor		*Culiseta particeps*	*Aedes sticticus*
				Aedes tahoensis
				Aedes ventrovittis
				Culiseta incidens
Woodland Pools	**Irrigated Pastures**	**Permanent Ponds**		
Aedes bicristatus	*Aedes dorsalis*	*Aedes niphadopsis*		
Aedes increpitus	*Aedes melanimon*	*Aedes schizopinax*		
Aedes washinoi	*Aedes nigromaculis*	*Anopheles occidentalis*		
Aedes punctipennis	*Aedes thelcter*	*Culex anips*		
Culex apicalis	*Aedes vexans*	*Culex erythrothorax*		
Culex tarsalis	*Anopheles freeborni*	*Culex reevesi*		
Culex thriambus	*Culex tarsalis*	*Culex tarsalis*		
Culiseta incidens	*Culiseta inornata*	*Culiseta impatiens*		
Culiseta inornata	*Psorophora columbiae*	*Culiseta incidens*		
Culiseta particeps	*Psorophora signipennis*	*Culiseta particeps*		
		Culiseta inornata		
		Coquillettidia perturbans		
		Uranotaenia anhydor		

*Compiled from: Identification of the Mosquitoes of California. Rev. 1998. Mosquito and Vector Control Association of California.

Appendix F
Insect Repellents

A number of products have been developed and registered by the Environmental Protection Agency for human use that repel adult mosquitoes and thus reduce the chances of mosquito bites. The most commonly used mosquito repellents contain the active ingredient DEET (N,N-diethyl-meta-toluamide), which has been formulated and sold under a variety of trade names. Repellents are available in a variety of concentrations and are formulated as aerosol sprays (most commonly at 15%), lotions, and solids (up to 100%). Spray repellents can be used on outer clothing as well as sparingly on the skin to ensure complete coverage. Repellents should not be used under clothing. The percentage of DEET in the repellent reflects the approximate length of time the product will repel mosquitoes (e.g., 23.8% DEET = about five hours of protection, 20% = about four hours, and 6.6% DEET = about two hours).

Topical repellents that contain picaridin, IR-3535, and oil of lemon eucalyptus are similar in efficacy to those with DEET, but often require more frequent application. Clothing and other materials impregnated with permethrin during manufacture are also available. It is important to always carefully read and understand the benefits and limitations of repellents listed on the product label before use. By law, all repellent products must be used according to their labels.

Appendix G
Additional Resources and Information

Mosquito Biology

Additional information on mosquitoes and mosquito-borne diseases is easily obtainable from a variety of reputable sources. More information on mosquito biology and ecology is available on the American Mosquito Control Association (AMCA) and the Mosquito and Vector Control Association of California (MVCAC) websites. Local mosquito and vector control agencies and their respective websites can provide detailed information about local mosquito species. Information on mosquito-borne diseases is available from the Centers for Disease Control and Prevention (CDC) and the CDPH websites. Contact information for local mosquito and vector control agencies in California can be found through the CDPH website by entering the zip code of the location of interest under "**Locate Your Local Mosquito and Vector Control Agency**" at http://www.westnile.ca.gov/; more information is available on the MVCAC website.

Monitoring Mosquitoes and Diseases

More information about reporting dead birds and WNV surveillance in California can be found at http://www.westnile.ca.gov/.
Methods for sampling adult mosquitoes and guidelines for designing, operating, and processing of traps are discussed in Guidelines for Integrated Mosquito Surveillance (Meyer et al. 2003) and are summarized in Appendix B of the California Mosquito-Borne Virus Surveillance and Response Plan which can be found at: http://www.westnile.ca.gov/resources.php

The Centers for Disease Control and Prevention, Epidemic/Epizootic West Nile Virus in the United States: Guidelines for Surveillance, Prevention and Control http://cdc.gov/ncidod/dvbid/westnile/resources/wnv-guidelines-aug-2003.pdf

- Walton WE. 2005. Protocol for Mosquito Sampling for Mosquito Best Management Practices on State of California-Managed Wildlife Areas. University of California.

Health Department Websites

California Department of Public Health West Nile virus (WNV) website: http://www.westnile.ca.gov

United States Center for Disease Control and Prevention website: http://cdc.gov

US Centers for Disease Control and Prevention – West Nile Virus website: http://cdc.gov/ncidod/dvbid/westnile/index.htm

Disease Surveillance Websites

UC Davis Center for Vectorborne Diseases website: http://cvec.ucdavis.edu

California Vectorborne Disease Surveillance Gateway website: http://www.calsurv.org/

Best Management Practices

Best Management Practices for Mosquito Control on California State Properties: http://www.westnile.ca.gov/resources.php

- For additional information on personal protective measures and the use of chemical repellents, go to the Centers for Disease Control and Prevention (CDC) web site at: http://www.cdc.gov/ncidod/dvbid/westnile/RepellentUpdates.htm
- For more information on evaluating the efficacy of BMPs on state of California-managed Wildlife Areas, see Walton 2005.

Mosquito Control

American Mosquito Control Association website: http://www.mosquito.org

Mosquito and Vector Control Association of California website: http://www.mvcac.org

University of California at Davis Center for Vectorborne Diseases website: http://cvec.ucdavis.edu

University of California IPM Online website: http://www.ipm.ucdavis.edu/

State Water Resources Control Board NPDES General Permits: http://www.waterboards.ca.gov/water_issues/programs/npdes/aquatic.shtml#davcp

Additional Online Resources

Climate Information

National Weather Service – Climate Prediction Center website: http://www.cpc.ncep.noaa.gov/products/predictions

Water Related Information

California Data Exchange Center website: http://cdec.water.ca.gov

Pesticide and Insect Repellent Information

National Pesticide Telecommunications Network website: http://npic.orst.edu/factsheets/DEETgen.pdf

National Pesticide Information Center website: http://npic.orst.edu/

Agriculture and Crop Related Information

California Agricultural Statistics Service website: http://www.nass.usda.gov/ca

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List of Acronyms

AMCA	American Mosquito Control Association
BMP	Best Management Practices
Bs	Bacillus sphaericus
Bti	Bacillus thuringiensis israelensis
CDC	Centers for Disease Control and Prevention
CDPH	California Department of Public Health
CVEC	Center for Vectorborne Diseases (UC Davis)
DFG	California Department of Fish and Game
CDPR	California Department of Pesticide Regulation
EPA	Federal Environmental Protection Agency
H&S Code	California Health and Safety Code
MVCAC	Mosquito and Vector Control Association of California
NPDES	National Pollution Discharge Elimination System
SLE	St. Louis encephalitis virus
SWRCB	State Water Resources Control Board
UCD	University of California, Davis
WEE	Western equine encephalomyelitis virus
WNV	West Nile virus

Integrated Vector Management Program

Marin/Sonoma Mosquito & Vector Control District

Final Programmatic EIR
June 2016

Responses to Comments
Text Changes

State Clearinghouse No.
2012052066

MARIN/SONOMA MOSQUITO & VECTOR CONTROL DISTRICT

Protecting Public Health Since 1915

Document Information

Prepared for	Marin/Sonoma Mosquito & Vector Control District
Project Name	Integrated Vector Management Program Final Programmatic Environmental Impact Report Responses to Comments Text Changes
Date	June 2016
State Clearinghouse No.	2012052066

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1 Introduction

This Responses to Comments document has been prepared by the Marin/Sonoma Mosquito and Vector Control District to accompany the Draft Programmatic Environmental Impact Report (Draft PEIR) for the proposed Integrated Vector Management Program (IVMP). The Draft PEIR identified the environmental consequences associated with a range of chemical and nonchemical treatment alternatives (components/methods/tools) for its ongoing program of surveillance and control of mosquitoes and other vectors of human and animal disease and discomfort. It includes discussion of best management practices (BMPs) to avoid and/or minimize potential impacts and additional proposed mitigation measures to reduce potentially significant impacts to less than significant. The Responses to Comments document presents responses to public comments received on the Draft PEIR, and it makes revisions to the Draft PEIR text and appendices, as necessary, in response to the comments. **Together with the Draft PEIR (dated August 2015), this Responses to Comments/Text Changes document constitutes the Final PEIR for the District's proposed IVMP.**

The District is the lead agency under the California Environmental Quality Act (CEQA) with responsibility for preparing responses to public comments and the Final PEIR. The Final PEIR is an informational document that must be considered by the District's Board of Trustees (decision makers) before approving or denying the Proposed Program. The CEQA Guidelines (§15132) require the following contents to be included in the Final PEIR:

a. Draft PEIR or a revision of the draft

b. Comments and recommendations received on the Draft PEIR, either verbatim or in summary

c. A list of persons, organizations, and public agencies commenting on the Draft PEIR

d. Responses of the lead agency (MSMVCD) to significant environmental points raised in the review and consultation process

e. Any other information added by the lead agency

1.1 Environmental Review Process

The District released the Integrated Vector Management Program Draft PEIR on August 13, 2015, for public review (State Clearinghouse No. 2012052066). The 50-day public review (45 days minimum plus 5 extra days) and comment period began on August 14 and concluded on October 2. During this time, the District held three public hearings at San Rafael (September 15), Santa Rosa (September 17), and Petaluma (September 21), California, within the Program Area.

The State of California Governor's Office of Planning and Research State Clearinghouse and Planning Unit provided a letter dated September 29, 2015, that the District has complied with the State Clearinghouse review requirements for draft environmental documents pursuant to the California Environmental Quality Act. This letter is provided herein at the end of this chapter.

Section 21092.5 of the Public Resources Code requires that the lead agency provide the "written proposed response" to a public agency on comments made by that public agency on the EIR at least 10 days before the lead agency certifies the document. See also State CEQA Guidelines §15088(b). Each written response describes the disposition of significant environmental issues raised by the commenter. Although optional under CEQA, the District has also distributed written responses to the nonpublic organizations and individuals for at least 10 days prior to PEIR certification. The Responses to Comments/Text Revisions document of the Final PEIR also has been posted on the District's website approximately 10 days before PEIR certification.

The District Board of Trustees will consider the PEIR, including all comments and responses, prior to certification of the Final PEIR. Certification is a finding that the PEIR complies with the requirements of CEQA. Following PEIR certification and upon approval of alternatives to comprise the IVMP, the Board shall make findings for each significant environmental impact that are supported by substantial evidence in the record and shall adopt the Mitigation Monitoring Program (MMP).

Based upon material contained in the responses to comments and minor revisions of the Draft PEIR provided in the Final PEIR, recirculation of the PEIR is not required under the CEQA Guidelines §15088.5 because no new significant information has been added to the PEIR, and under subsection (b) recirculation is not required where the new information added merely clarifies or amplifies or makes insignificant modifications to an adequate EIR.

1.2 Report Organization

This Responses to Comments document and Final PEIR contains the following chapters with a brief explanation of chapter contents.

> **Chapter 2. Public Agency Comments and Responses:** Comments received from state agencies (3) and one local agency are provided with District responses following each letter.

> **Chapter 3. Organization Comments and Responses:** Four letters were provided from private organizations, special interest groups, and an attorney representing groups and an individual. District responses to comments follow each letter or attachments to a letter.

> **Chapter 4. Individual Comments and Responses:** The District received 13 emails and handouts from individuals. In one case, an individual provided multiple emails and handouts (8). The letters and responses are provided alphabetically.

> **Chapter 5. Public Hearing Comments and Responses:** On September 15, 17, and 21, 2015, the District held public hearings on the Draft PEIR. At the first two hearings, in San Rafael and Santa Rosa, one person in attendance provided oral comments, and a transcript of public comments is provided for these two hearings. No one in attendance provided comments at the third hearing in Petaluma.

> **Chapter 6. Revisions to Draft PEIR:** This chapter presents minor revisions to text and appendices based on comments received or errors/errata discovered by the PEIR preparers. None of these text changes result in any changes to the conclusions and determinations of significant impact. In other words, no “less-than-significant” impacts were changed to “potentially significant” or “significant and unavoidable” impacts.

The following is a list of all public agencies (coded S [state], L [local]), private organizations (coded O), and private individuals (coded I) who submitted written comments on the Draft PEIR during the comment period. Each letter is assigned a code that includes at least three letters for the agency, organization, or individual name. If multiple letters were submitted, they are numbered.

Public Agencies

S-CDFW	California Department of Fish and Wildlife, Bay Delta Region
S-DOT	California Department of Transportation
S-DPR	California Department of Parks and Recreation, Bay Area District
L-NMWD	North Marin Water District

Private Organizations

O-MAS	Marin Audubon Society
O-MCGP	Marin County Green Party
O-RRK	Russian Riverkeeper
O-VOL	Stephan C. Volker Law Offices (Pesticide Free Marin in 2016, Turning Green, Coast Action Group, Sustainable TamAlmonte, and Mary Fraser)

Private Individuals

I-Dic	Pat Dickens
I-Fra1	Mary Fraser
I-Fra2	Mary Fraser
I-Fra3	Mary Fraser
I-Fra4	Mary Fraser
I-Fra5	Mary Fraser
I-Fra6	Mary Fraser
I-Fra7	Mary Fraser
I-Fra8	Mary Fraser
I-Joh	Dale Johnson
I-Leg	Dan Legacy
I-Per	Michael Peri
I-Spe	Suzanne Speh

Public Hearings

T-San Rafael	Transcripts of Proceedings Taken at San Rafael, California
T-Santa Rosa	Transcripts of Proceedings Taken at Santa Rosa, California
T-Petaluma	Transcripts of Proceedings Taken at Petaluma, California

In the responses, references may be made to responses to a different commenter. For example, if the commenter is directed to see response O-VOL-22, that reference will be to response to comment 22 in the letter labeled O-VOL.

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STATE OF CALIFORNIA

GOVERNOR'S OFFICE *of* PLANNING AND RESEARCH

STATE CLEARINGHOUSE AND PLANNING UNIT

EDMUND G. BROWN JR.
GOVERNOR

KEN ALEX
DIRECTOR

September 29, 2015

Philip D. Smith
Marin-Sonoma Mosquito and Vector Control District
595 Helman Lane
Cotati, CA 94931

Subject: Integrated Vector Management Program PEIR
SCH#: 2012052066

Dear Philip D. Smith:

The State Clearinghouse submitted the above named Draft EIR to selected state agencies for review. On the enclosed Document Details Report please note that the Clearinghouse has listed the state agencies that reviewed your document. The review period closed on September 28, 2015, and the comments from the responding agency (ies) is (are) enclosed. If this comment package is not in order, please notify the State Clearinghouse immediately. Please refer to the project's ten-digit State Clearinghouse number in future correspondence so that we may respond promptly.

Please note that Section 21104(c) of the California Public Resources Code states that:

> "A responsible or other public agency shall only make substantive comments regarding those activities involved in a project which are within an area of expertise of the agency or which are required to be carried out or approved by the agency. Those comments shall be supported by specific documentation."

These comments are forwarded for use in preparing your final environmental document. Should you need more information or clarification of the enclosed comments, we recommend that you contact the commenting agency directly.

This letter acknowledges that you have complied with the State Clearinghouse review requirements for draft environmental documents, pursuant to the California Environmental Quality Act. Please contact the State Clearinghouse at (916) 445-0613 if you have any questions regarding the environmental review process.

Sincerely,

Scott Morgan
Director, State Clearinghouse

Enclosures
cc: Resources Agency

Document Details Report
State Clearinghouse Data Base

SCH#	2012052066
Project Title	Integrated Vector Management Program PEIR
Lead Agency	Marin-Sonoma Mosquito and Vector Control District

Type	**EIR** Draft EIR
Description	The Marin/Sonoma Mosquito and Vector Control District undertakes activities through its Integrated Vector Management Program (IVMP) to control the following vectors of disease and/or discomfort within its two-county Service Area: mosquitoes, rats, yellow jackets, midges, and ticks. (A vector is defined as "any animal capable of transmitting the causative agent of human disease or capable of producing human discomfort or injury..." (The CA Health and Safety Code, Section 2200(f)). The District is preparing a PEIR to evaluate the effects of the continued implementation of the control strategies and methods prescribed in its IVMP.

Lead Agency Contact

Name	Philip D. Smith		
Agency	Marin-Sonoma Mosquito and Vector Control District		
Phone	707 285 2204	*Fax*	
email			
Address	595 Helman Lane		
City	Cotati	*State* CA	*Zip* 94931

Project Location

County	Marin, Sonoma			
City	San Rafael, Novato, Petaluma, Santa Rosa			
Region				
Lat / Long				
Cross Streets	NA - possible activities throughout the two Counties			
Parcel No.				
Township		*Range*	*Section*	*Base*

Proximity to:

Highways	Hwy 37, 116, 121, 128
Airports	Santa Rosa, Petaluma, Novato
Railways	SMART, NWP
Waterways	Russian River, Petaluma River
Schools	
Land Use	NA-covers all cities and unincorporated area within 2 counties as well as unincorporated area, developed and undeveloped

Project Issues	Air Quality; Biological Resources; Noise; Public Services; Recreation/Parks; Septic System; Toxic/Hazardous; Vegetation; Water Quality; Water Supply; Wetland/Riparian; Landuse; Cumulative Effects; Other Issues
Reviewing Agencies	Resources Agency; Department of Boating and Waterways; California Coastal Commission; Department of Fish and Wildlife, Region 3; Department of Parks and Recreation; San Francisco Bay Conservation and Development Commission; Department of Water Resources; Caltrans, District 4; Air Resources Board; Regional Water Quality Control Board, Region 1; Regional Water Quality Control Board, Region 2; Native American Heritage Commission; State Lands Commission; Department of Pesticide Regulation

Date Received 08/14/2015 ***Start of Review*** 08/14/2015 ***End of Review*** 09/28/2015

Note: Blanks in data fields result from insufficient information provided by lead agency.

2 Public Agency Comments and Responses

Comment Letter S-CDFW 2-9
California Department of Fish and Wildlife 2-9
Comment Letter S-DOT 2-26
California Department of Transportation 2-26
Comment Letter S-DPR 2-30
California Department of Parks and Recreation 2-30
Comment Letter L-NMWD 2-36
North Marin Water District 2-36

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State of California – The Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Bay Delta Region
7329 Silverado Trail
Napa, CA 94558
(707) 944-5500
www.wildlife.ca.gov

***EDMUND G. BROWN JR.**, Governor*
***CHARLTON H. BONHAM,** Director*

S-CDFW

October 13, 2015

Mr. Philip D. Smith, District Manager
Marin Sonoma Mosquito & Vector Control District
595 Helman Lane
Cotati, California 94931

Dear Mr. Smith:

Subject: Marin Sonoma Mosquito & Vector Control District Integrated Vector Management Program, Draft Programmatic Environmental Impact Report, SCH #2012052066, Marin and Sonoma Counties

The California Department of Fish and Wildlife (CDFW) has reviewed the draft Programmatic Environmental Impact Report (PEIR) for the Marin Sonoma Mosquito & Vector Control District (District) Integrated Vector Management Program (Project). CDFW is providing comments on the draft PEIR as a Trustee Agency and Responsible Agency. On September 11, 2015, CDFW received your approval to extend the comment period for CDFW to October 14, 2015.

As Trustee for the State's fish and wildlife resources, CDFW has jurisdiction over the conservation, protection, and management of the fish, wildlife, native plants, and the habitat necessary for biologically sustainable populations of such species for the benefit and use by the people of California. CDFW also acts as a Responsible Agency pursuant to the California Environmental Quality Act (CEQA) CEQA Section 15381 if a project requires discretionary approval, such as issuance of a California Endangered Species Act (CESA) Incidental Take Permit (ITP) (Fish and Game Code section 2080 *et seq.*), or Lake or Streambed Alteration Agreement (LSAA) (Fish and Game Code section 1600 *et seq.*).

CDFW is submitting comments on the draft PEIR to inform the District of our concerns over potential impacts, recommend changes to the District's Best Management Practices (BMPs), and suggest changes in the document.

Project Location and Description

The proposed Project area for the draft PEIR consists of the District's Service Area boundaries, and includes all lands located within Marin and Sonoma Counties, and the four adjacent counties of Napa, Lake, Mendocino, and Solano where service may be provided upon request. The proposed Project area includes watersheds, such as but not limited to, the Russian River, Petaluma River, Sonoma Creek, Lagunitas Creek, Corte Madera Creek and San Pablo Bay. Vector control activities are conducted at a wide variety of locations and sites throughout the District's Service Area, including tidal marshes, duck clubs, other diked marshes, lakes and ponds, rivers and streams, vernal pools and other seasonal wetlands, stormwater detention basins, flood control channels, spreading grounds, street

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drains and gutters, wash drains, irrigated pastures, and agricultural ditches, as well as animal troughs, artificial containers, tire piles, fountains, ornamental fishponds, swimming pools, liquid waste detention ponds, and non-natural harborage (such as covered wood piles, residential and commercial landscape, trash receptacles).

The District undertakes vector control activities through its Program to control and/or provide information on the following vectors of disease and/or discomfort in the Program Area: mosquitoes, cockroaches, fleas, flies, rats, mice, ticks, and yellow jackets. The District also performs vegetation management (including control of noxious and/or invasive plants) to facilitate access to vector habitat, improve efficiency and effectiveness of mosquito control operations, and as a source reduction measure.

The proposed Project consists of the following "tools" or components, which are described as alternatives: surveillance, physical control, vegetation management, biological control, chemical control, and nonchemical control/trapping. The proposed project is a combination of these alternatives with the potential for all of these alternatives to be used in their entirety along with public education.

General Comments

Best Management Practice (BMP) A-2 states that 'wildlife studies' will be included in communication with resource agency staff, please outline any proposed wildlife studies. The PEIR should assume presence of special-status species where suitable habitat occurs unless protocol-level surveys are conducted. The PEIR should include the specific survey protocols that will be used in each habitat type and associated special-status species. *Survey and Monitoring Protocols and Guidelines* are available at CDFW's website: https://www.dfg.ca.gov/wildlife/nongame/survey_monitor.html. 1

Many of the District's BMPs rely on future input, training, and coordination with and from CDFW and other regulatory agencies. CDFW highly encourages coordination with CDFW land mangers on CDFW-owned land, but recommends that the District's BMPs be refined to avoid or reduce reliance on CDFW staff. For example, BMP E-3 relies on CDFW to inform District staff of the locations of endangered plants for flagging and District staff avoidance. For lands outside of CDFW ownership, the District should implement rare plant surveys performed by a qualified botanist or coordinate with independent qualified botanists to determine species occurrences and locations. Moreover, CDFW would discourage the flagging of species occurrence due to the inadvertent attention it may bring them. 2

Proposed BMPs A-7 and H-10, rely on positive occurrences databases such as the California Natural Diversity Database (CNDDB) for site screening. The CNDDB only represents the data that have been submitted and does not provide an exhaustive list of species or habitat type, and therefore, the CNDDB does not provide an exhaustive list of species distribution. It is unclear in BMP H-10, how suitable habitat will be determined. CDFW recommends that the potential presence of special-status species at Project sites be based on a detailed assessment of suitability of habitat for fish and wildlife species using 3

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various methods such as aerial imagery, historical and recent survey data, field reconnaissance, site-specific surveys, scientific literature and reports, as well as "positive occurrence" databases such as CNDDB.

CDFW considers the migratory bird nesting season in Sonoma and Marin counties to be February 1 through August 31. BMP F-6 should be changed to reflect this nesting season. 4

The District should clarify in BMP A-10 and B-4 that the possible spread and transmission of fungal pathogens from worker footwear, tools and ATV's that causes Chitridiomycosis would be addressed by decontamination of wetland/vernal pool work equipment. Chytridiomycosis is an amphibian fungal disease caused by *Batrachochytrium dendrobatiditis.* Chytridiomycosis has been implicated as an important factor in the decline of amphibians worldwide. To prevent the potential spread of this amphibian fungal pathogen throughout Marin and Sonoma County wetlands, a decontamination protocol for District field workers and their equipment should be implemented. As such, BMP-10 should be revised to state that field equipment, worker boots and vehicles that have been in contact with wetlands, shall be decontaminated before and after entering wetlands in different watersheds. For guidance and further detail please refer to "*Interim Guidance on Site Assessment and Field Surveys for Determining Presence or a Negative Finding of the California Tiger Salamander*," October 2003 (https://www.dfg.ca.gov/wildlife/nongame/survey_monitor.html#Amphibians). 5

Additionally, CDFW is concerned with the spread of invasive upland and aquatic non-native weeds. Weed seeds may be transported from property to property on District field equipment, especially vehicles such as ATV's. Invasive weeds typically produce homogenous stands that out-compete native plants and reduce overall biodiversity. The District's BMP list should include a provision that details the removal of weed seeds from field equipment including the undercarriages of vehicles (e.g. by using an air compressor) between properties entered on the same day to further reduce the spread of invasive and nonnative plants and animals. 6

Surveillance Alternative

The draft PEIR states that activities associated with the Surveillance Alternative would have a less-than-significant impact (page 4-76 and 77). This Surveillance Alternative includes activities such as maintaining paths and long-term clearing of vegetation to allow access, which may have an impact to Biological Resources. Within the Project area, direct and indirect impacts on special-status species may be significant due to habitat loss, physical crushing by motorized vehicles or consistent disturbance. For example, regular vegetation maintenance in tidal marsh habitats may be a significant impact on salt-marsh harvest mouse (*Reithrodontomys raviventris*), California black rail (*Laterallus jamaicensis coturniculus*) and California clapper rail (*Rallus obsoletus obsoletus*), all identified as Fully Protected pursuant to Fish and Game Code sections 3511 and 4700. Fully Protected species may not be taken or possessed at any time and no licenses or permits may be issued for their take except for collecting these species for necessary scientific research. Since the extent of salt marsh vegetation removal is unknown, the actual impact on species is also unknown. 7

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To avoid any impacts to salt marsh harvest mouse, CDFW recommends that BMP C-2 state that vegetation removal will be done by hand and BMP A-8 state that no vehicles shall be driven within salt marsh habitat. Vehicles, either mounted mowers or ATV off-road vehicles, do not allow time for salt marsh species to move into adjacent areas. 8

CDFW recommends changing District's BMP D-3 and G-3 work window for California clapper rail avoidance to September 1 through January 15 to avoid courtship activities and behavior that begin prior to the onset of the breeding season. 9

CDFW is concerned that the proposed project has the potential to impact the California tiger salamander (CTS), a state-threatened species. The PEIR should determine the habitat location and quantify what the impacts are to CTS, and then present biological measures, such as take avoidance and minimization measures. The PEIR should identify mitigation for any impacts to potential breeding and/or upland habitat to conclude that the impacts have been mitigated to less-than-significant levels. CDFW recommends that BMP F-10 state that no motor vehicles be operated in vernal pool habitat during California tiger salamander (CTS) (*Ambystoma californiense*) breeding and rearing season and during rare plant growth and blooming seasons. Any access through or across vernal pools and swales should be done by foot. The draft PEIR states that District staff would cross hydrologic connection (swales) with permission from regulatory agencies. If the swale contains CTS or state listed plants, an Incidental Take Permit may be needed. It should therefore be stated in the draft PEIR that an Incidental Take Permit may be needed when working in threatened or endangered species habitats. In addition, because CTS is a federally listed species, we recommend contacting the U.S. Fish and Wildlife Service regarding impacts to this species. 10

CDFW discourages aerial treatments (helicopter and fixed wing) over vernal pool and salt marsh habitats. According to District BMP H-13, appropriate agencies will be notified in advance of large scale treatments to sensitive areas. Salt marsh and vernal pool habitats are sensitive habitats, and CDFW should be notified of any planned large scale treatment. 11

Physical Control Alternative

Section 4.2.4 of the draft PEIR addresses the physical control alternative which deals with modifying the landscape to reduce vector habitat. These landscape modifications are described as filling of nonfunctional water circulation ditches, reconnecting backwaters or isolated pools on floodplains, and increasing drainage rates and areas in managed wetlands. It further states that draining areas of shallow freshwater habitat to reduce the amount of standing water or reduce the amount of time such water remains standing may be required in some circumstances. The draft PEIR outlines BMPs in Table 4-6 Section G for water structures in Waters of the U.S., yet the exact impacts of each site are unknown. CDFW recommends that the District evaluate potential impacts and provide feasible and foreseeable avoidance, minimization, and mitigation measures in the PEIR, and not defer mitigation to consultation with agencies. CDFW also recommends including jurisdictional state waters to Section G. 12

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If specifics are not available at this point to be analyzed within the scope of this draft PEIR then all future landscape modifications under the Physical Control Alternative should be independently analyzed under separate CEQA review. 13

Food Web Impacts

Sections 4.2.2.6 and 5.2.2.2.4 of the draft PEIR discuss ecological food webs in broad concepts. Aquatic invertebrates, including mosquito larvae, serve as food resources for fish, including salmonids as well as amphibians. Vector control techniques, such as the use of a mosquito larvacide can result in a loss of available prey, which could affect fish and amphibian growth, reproduction (Lawrenz 1984) and survival. The draft PEIR, Page 4-75 acknowledges that mosquito larvae control by the District likely reduces the amount of available prey for amphibians; however, states that no impact is expected to occur to amphibians because vector controls are applied over a "small area" and other prey species are available to amphibians. The Sonoma County population of CTS occupies a very restricted area limited to vernal pools on the west side of the city of Santa Rosa. CDFW is aware that many vernal pools occupied by CTS have been treated with mosquito larvacide, despite the lack of information on the potential adverse impact of prey removal on CTS. CDFW recommends that the PEIR address this potentially significant impact. Natural predators should be used as the first line of defense on larvae. The District should develop abundance thresholds in sensitive habitats (i.e. vernal pools) that guide treatment. Intensive monitoring should be conducted to demonstrate exponential growth patterns prior to treatment of vernal pools. 14

CDFW Coordination

CDFW recognizes and appreciates the District's intent to coordinate with CDFW Environmental Scientists and Land Managers with regard to District activities on CDFW-owned land. BMP G-2 should include a meeting with CDFW and the District annually, prior to the onset of the rainy season, to discuss, among other things: access, sensitive resources, weed and pathogen spread, treatment alternatives, and treatments applied. In addition, the annual report should detail what properties were accessed and when, vector survey results, and treatments implemented on CDFW properties during the prior year. 15

California Endangered Species Act

CDFW has regulatory authority over projects that could result in the "take" of any species listed by the State as threatened, endangered or candidate, pursuant to Fish and Game Code §2050 et seq. and or plants protected by the Native Plant Protection Act. Please be advised that a CESA Permit, pursuant to Fish and Game Code §2050 et seq., must be obtained if the Project has the potential to result in take of species of plants or animals listed under CESA, either during Project activities or over the life of the Project. Issuance of a CESA Permit is subject to CEQA documentation; therefore, the PEIR must specify impacts, mitigation measures, and a mitigation monitoring and reporting program. If the proposed Project will impact CESA-listed species, early consultation with CDFW is encouraged, as significant modification to the Project and mitigation measures may be required in order to obtain a CESA Permit. More information about the CESA permit process can be found on the CDFW website at https://www.wildlife.ca.gov/Conservation/CESA. 16

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Lake and Streambed Alteration Agreement

CDFW may require an LSAA, pursuant to Fish and Game Code §1600 et seq. Notification is required for any activity that will divert or obstruct the natural flow, change the bed, channel, or bank including associated riparian or wetland/marsh resources, use material from the stream/channel bed, or substantially adversely affect fish and wildlife resources. Issuance of an LSAA is subject to CEQA. CDFW, as a Responsible Agency under CEQA, will consider the CEQA document for the Project. Therefore, the CEQA document must specify impacts, mitigation measures, and include a mitigation monitoring and reporting program. More information about the LSAA process can be found on the CDFW website at https://www.wildlife.ca.gov/Conservation/LSA. 17

CDFW appreciates the opportunity to provide comments on the draft PEIR for the proposed Project and is available to meet with you to further discuss our concerns. If you have any questions, please contact Timothy S. Dodson, Environmental Scientist, at (707) 944-5513; or Ms. Karen Weiss, Senior Environmental Scientist (Supervisory), at (707) 944-5525.

Sincerely,

Scott Wilson
Regional Manager
Bay Delta Region

cc: State Clearinghouse

Mr. Ryan Olah
U.S. Fish and Wildlife Service
Ryan_Olah@fws.gov

Mr. Douglas Hampton
National Marine Fisheries Service
douglas.hampton@noaa.gov

Literature Cited

Lawrenz, R.W. 1984. The response of invertebrates in temporary vernal wetlands to Altosid SR-10 used in mosquito abatement programs. Journal of the Minnesota Academy of Sciences 50(3): 31-33.

Comment Letter S-CDFW — California Department of Fish and Wildlife

Scott Wilson, Regional Manager
October 13, 2015

Response 1

Given the size of the District's Service Area and the hundreds of individual surveillance and control sites that the District covers, it is infeasible for the District to perform "protocol" surveys at all locations for surveillance and for every treatment. Moreover, protocol level surveys at all treatment locations are not necessary to ensure that impacts on special-status (listed) species and their habitats would be less than significant. Implementation of the protective measures included through the BMPs are sufficient to ensure that the District's ongoing program activities will not have a substantial adverse effect on special-status species or their habitats. For example, see Response 9 for BMPs to avoid or minimize disturbances to salt marsh harvest mouse.

The PEIR analysis assumes that presence will be determined before physical or vegetation management "treatment" is conducted based on the BMPs. For selected Physical Control or Vegetation Management treatments, i.e., those which may require permits from CDFW, USFWS, USACE, or RWQCB, species occurrence information will be obtained using the latest databases (CNDDB and District), published reports, and consultation with resource agency staff. MSMVCD will assume presence for surveillance activities and implement avoidance measures to prevent take of state-listed species.

MSMVCD understands that CDFW wants assurance that the biological surveys will adequately determine presence of a special-status species. Surveys would be species-specific (i.e., fish, frogs, salamanders, various birds, plants, etc.) and somewhat habitat-specific and could be generalized for many groups of organisms (i.e., floristic surveys for plants in the appropriate seasons; possible protocol surveys for those species for which they are available such as CRLF and CTS; visual surveys for birds). However, it is known and understood that protocol surveys can be quite intensive, time-consuming (over multiple seasons or years), and costly, and the District does not have the financial resources to do them for its ongoing vector management activities throughout Marin and Sonoma counties (in contrast to the permanent, construction-related activities of land development or utility pipeline projects where protocol surveys are most often performed at site-specific locations). For some species, a survey may require capture of the species, which would require special permits (i.e., CTS larvae in waters with low visibility), which would be infeasible in light of the time-sensitive nature of the District's vector management activities when preparing for mosquito control outside of the wildlife refuges/management areas. Inside the federal and state wildlife refuges, District staff contact and work with the appropriate refuge staff to review control activities to be performed and rely on the refuges' surveys and data to augment literature/database information for special-status species.

The District did participate in an informal biological evaluation (IBE) of mosquito source reduction activities in tidal habitats of the San Francisco Bay Area. This IBE was completed for the renewal process of the District's nationwide mosquito source reduction permit under the regulatory authority of the US Army Corps of Engineers (USACE). The San Francisco Bay Conservation and Development Commission (BCDC) and the San Francisco Bay Regional Water Resources Control Board (RWQCB) are also permitting agencies for his work. The District analyzed the potential impacts of physical control/mosquito source reduction work on special status species in tidal marshes. This document has been reviewed by the USACE and US Fish and Wildlife Service (USFWS).

Specific survey protocols/methods for special-status species and their habitats can be developed for those specific sites determined to require such surveys and in consultation with CDFW. A District staff biologist with approved training for a particular species (or other professional biologist) would conduct the initial evaluation for sites that may require protocol surveys. Protocol surveys would need to be done by an

agency-approved biologist. Criteria for the initial evaluation would be developed in consultation with CDFW (and USFWS and NMFS as needed) and could be incorporated into the Mitigation Monitoring Program (MMP) for this PEIR. District staff will meet with CDFW to review sites most often requiring physical/vegetation control measures and develop a plan for determining presence of special-status species or presuming presence of such species and what additional protection measures (if any) are needed.

Response 2

The District visits hundreds of natural sites each year. Conducting surveys for and mapping of sensitive species for all these sites, particularly large expanses of private land and tidal marsh, is not feasible or appropriate for a programmatic analysis. To visit all of these sites at the appropriate time for vector control surveillance and treatment, and to avoid impacts on special-status species, the District provides training for all staff using information from CDFW materials, professional biologists, existing databases, and aerial photographs (Google Earth). Staff are provided pictures of rare plants and special status species, and calls of special-status bird species (e.g., rails) are put on their computers to raise awareness. All of the District's technical staff are required to take 40 hours of Continuing Education every 2 years that covers chemicals used in vector control, biology of species, and environmental sensitivity. BMP E3, which provide measures for the protection of the special-status plant species soft bird's beak, states that the District will coordinate with CDFW for activities at the Napa-Sonoma Marshes Wildlife Area, which encompasses 15,200 acres of baylands, tidal sloughs and wetland habitat. This does not imply that CDFW would be responsible for providing locations of soft bird's beak, but only that the District would use any available data CDFW has for locations of this plant within the Wildlife Area.

Flagging of soft bird's beak locations is a valid concern for vector control actions in or adjacent to areas regularly used by the public. However, this species generally is not expected to occur in areas heavily used by the public. Flagging could attract people to see what is being flagged with the potential for trampling of sensitive plant species. In areas not frequented by the public, flagging plant locations would assist the District and allow workers to avoid accidental damage to the plants. As noted above, staff are trained on how to identify special-status species, and this species will be included in their training when areas that could support soft bird's beak are to be visited by MSMVCD staff. Plant locations can be mapped when flagging occurs so staff know where they are likely to be in low public use areas. In high public use areas, staff will use maps of known locations and photos of the plants to avoid impacts.

For areas outside CDFW ownership, the District relies on existing data for soft bird's beak and other sensitive plant locations where such data are available. Sources of data include CNDDB, other plant databases (California Consortium of Herbaria), and local experts/botanists that may have unpublished data. If no data are available for new sites, and the vector control activities have the potential to adversely affect special-status plants (i.e., if suitable habitat is identified), specific surveys by a professional biologist would be performed. Plant locations can be recorded using GPS for mapping and future reference.

Response 3

Regarding comments on the District's approach to the evaluation of special-status species occurrence, the District acknowledges that lack of identification in CNDBB or other databases is not conclusive evidence that no sensitive species are present in potential treatment areas, or that they necessarily would not be there in the future. Suitable habitat referenced in BMP H10 will be determined using methods such as recent aerial photographs, results of previous survey data from scientific literature or reports, site-specific survey data, and databases such as CNDDB. The District presumes presence where suitable habitat occurs based on those biological investigations, which may include some protocol surveys at selected locations where District activity is of greatest concern. Moreover, visual observations by staff in the field can assist in assessing habitat suitability and in implementing measures to avoid or minimize impacts. For state-listed species, measures to avoid take will be implemented unless take cannot be avoided and a CESA permit has been obtained from CDFW. BMP H10 is modified as indicated below:

Special-Status Aquatic Wildlife Species:

> Suitable habitat will be determined using methods such as recent aerial photographs, results of previous survey data from scientific literature or reports, site-specific survey data, and databases such as CNDDB.

> A CNDDB search was conducted in 2012 and the results incorporated into Appendix A for this PEIR. An update was completed in November 2014 and the results incorporated into Section 4.1.2 of this PEIR. District staff communicates with state, federal, and county agencies regarding sites that have potential to support special status species. Many sites where the District performs surveillance and control work have been visited by staff for many years and staff is highly knowledgeable about the sites and habitat present. If new sites or site features are discovered that have potential to be habitat for special status species, the appropriate agency and/or landowner is contacted and communication initiated.

> Use only pesticides, herbicides, and adjuvants approved for aquatic areas or manual treatments within a predetermined distance from aquatic features (e.g., within 15 feet of aquatic features). Aquatic features are defined as any natural or man-made lake, pond, river, creek, drainage way, ditch, spring, saturated soils, or similar feature that holds water at the time of treatment or typically becomes inundated during winter rains.

> If suitable habitat for special status species is found, including vernal pools, and if aquatic-approved pesticide, herbicide, and adjuvant treatment methods have the potential for affecting the potential species, then the District will coordinate with the CDFW, USFWS, and/or National Marine Fisheries Service (NMFS) before conducting treatment activities within this boundary or cancel activities in this area. If the District determines no suitable habitat is present, treatment activities may occur without further agency consultation.

Given the large size of the Program Area and the number and diversity of sites treated, it is not feasible for the District to conduct detailed surveys at every location. The District is doing everything feasible short of this to determine the potential presence of special-status species through advance research and onsite visual observations by trained staff at the time of surveillance and control/treatment. The District also is implementing every feasible precaution and BMP to avoid or minimize impacts on special-status species.

Information from databases is just one tool to assess potential impacts. Because the PEIR covers a long-term, ongoing program over a vast area (1.5 million acres or 2,300 square miles), it is not feasible to know now whether a protected species will be present in a potential treatment area at the time treatment is proposed. For this reason the Draft PEIR identifies the types of species that may be present in the Program Area and their habitat (Tables 4-3 and 4-4), and impacts are evaluated by habitat type and type of activity, based on the species that could occur in those habitat types.

District policy is that its Integrated Vector Management Program (IVMP) be an adaptive management program protecting sensitive species and habitats while also providing effective vector management that uses IVM principles. BMPs, which are an integral part of the Program, are designed to ensure that the potential for special-status species to occur is assessed on an ongoing basis throughout the life of the IVMP, relying on a combination of tools including database searches, individualized habitat assessment and, where indicated based on habitat type, site-specific inspection and/or surveys, as warranted, as well as ongoing discussion of the District's activities with resource agencies. BMPs are regularly reviewed and updated to reflect the best available information and science. Furthermore, it is District policy that new BMPs be developed and added as needed to address new species and habitats of concern.

Response 4

BMP F6 specifies that vegetation management work will be conducted between October 1 and April 30 to minimize the potential for impacts on sensitive species, especially breeding birds. This is the "seasonal work period" contained in the District's Lake or Streambed Alteration Agreement (No. 1600-2010-0253-R3, dated October 6, 2010, and amended in 2012 and 2013). The District is aware that the migratory bird nesting season is considered to be February 1 through August 31. BMP F6 has been revised below to reflect these dates. The District will perform vegetation management as indicated in agency issued work permits.

> Vegetation management work will be generally confined to October 1 to April 30 to minimize potential impacts to sensitive species, especially breeding birds. ~~When~~ If work is expected to occur between February 1 and ~~April 30~~ August 31 (nesting season for migratory birds), additional consultations will occur with appropriate resource agencies to help identify locations of active nests of raptors or migratory birds as well as any additional protection measures that will need to be implemented prior to commencement of work.

Response 5

BMP A10 has been revised to include invasive animal species such as New Zealand mud snails and amphibian pathogens such as the chytrid fungus. District staff will be trained in locations where these are known or expected to occur and in equipment decontamination methods if such areas cannot be avoided.

> Properly train all staff, contractors, and volunteer help to prevent spreading weeds and ~~pests~~invasive animal species (e.g., New Zealand mud snails) or pathogens (e.g., the fungus that causes chytridiomycosis in amphibians) to other sites. The District headquarters contains wash rack facilities (including high-pressure washers) to regularly (in many cases daily) and thoroughly clean equipment to prevent the spread of weeds. In addition, MSMVCD will provide equipment, such as an air compressor, to clean equipment in the field when there is a concern about the transfer of weed seeds. Decontamination methods to clean equipment and personnel clothes, such as boots, of invasive species and pathogens will be included in worker training and be implemented when working in wetlands in different watersheds.

For invasive plants, equipment such as ATVs are cleaned of visible plant material in the field before moving to another area. Staff are trained regarding known locations of invasive plants, and work is scheduled for noninfested areas prior to infested areas whenever feasible. Vehicles and equipment are cleaned using high-pressure wash racks at the District's equipment storage location behind the District office.

Response 6

We agree that the spread of invasive plant species is a concern when vehicles and equipment move from one location to another. The concern is not related to property boundaries, however, because ecological characteristics that drive weed infestations do not necessarily follow property lines. The District takes this concern very seriously, and supervisorial staff regularly educate field staff about highly invasive species such as pepperweed (*Lepidium latifolium)* that are frequently encountered. In addition, the District coordinates closely with Refuge staff regarding weed infestations and how to avoid their spread. We have provided assistance with and have partnered in invasive plant control investigations (e.g., pepperweed and *Ludwigia* ssp.). Staff are instructed to clean equipment after exposure to weed infested areas to limit seed dispersal. More detail has been added to BMP A10 (shown above under Response 5) to address training that is conducted on this topic.

The District is not aware of any weed infestations that have occurred due to their activities. To the contrary, the District regularly supports invasive plant/weed removal efforts for private landowners (e.g., pepperweed and *Ludwigia* ssp.).

In addition, several of the BMPs protect lands from invasive plant species: see BMPs A10: training, cleaning protocol and cleaning equipment; B4: cleaning vehicles and gear prior to entering marshes; G16: side cast materials inspected for weed infestations and abatement procedures. We anticipate that better results are achieved from these highly focused activities in specific areas that support invasive species than would be achieved by routinely cleaning equipment after each property.

Response 7

The type of vegetation removal under the Surveillance Alternative is limited to maintaining access to sites regularly monitored rather than modifying mosquito-breeding habitat, which is part of the Vegetation Management Alternative. Maintenance of paths to facilitate sampling and to provide access to vector habitat is described under Section 2.3.1.1 on page 2-9. In comments on MSMVCD activities under the Surveillance Alternative, CDFW should note that:

> Most of the access ways are preexisting, and few new access pathways are created in any year.

> Access ways are only 3 to 6 feet wide (page 4-75 of the Draft PEIR).

> Vegetation is only trimmed when necessary to allow access for vector management activities, and only overhanging limbs generally 3 inches in diameter or less are cut.

We disagree that impacts on special-status species may be significant due to habitat loss or consistent disturbance from surveillance activities. The CEQA definition of substantial adverse change/significant impact vs less-than-significant impact (minor, short term, limited effects) is based on the physical change to the environment over the existing condition (i.e., May 25, 2012, when the NOP was issued). Habitat loss is extremely limited because few new access ways would be created in natural areas and because of the small size of these access ways (see above). The area of disturbance is extremely small in relation to the total potential sensitive species habitat area. No access has been wider than 6 feet and, as stated in the Draft PEIR (page 4-75) is usually about 3 feet wide and only what is the minimum needed.

Surveillance is a monitoring activity that focuses on sampling, not habitat alteration. Vegetation trimming to facilitate surveillance by itself would have a less-than-significant impact on habitat and the species depending on that habitat, especially since vegetation is being trimmed/maintained and not completely removed or cleared. As described in Section 2.3.1.1, of the PEIR, paths will be maintained only when other alternatives for access do not exist, and paths typically will range in width between 3 and 6 feet. The District also disagrees that Program activities would result in consistent disturbance or that any such activities would result in significant impacts. As explained on pages 4-76 and 5-39 of the Draft PEIR: “These disturbances would be very minor and of short duration, so would likely not cause these animals to abandon the area, but rather move away from the activity while it is occurring.” Surveillance is also an infrequent activity. In any given area, District staff would typically be on site to conduct surveillance activities less than once every six days, and then only when necessary for mosquito control treatments and follow-up surveillance. These surveillance and control activities are also seasonal or seasonally reduced depending on habitat and potential for production of a particular mosquito species. For example, during the winter months, mosquito surveillance and control ceases or is substantially reduced in seasonal wetlands (including vernal pools), creeks, and tidal marshes. Quantifying number and timing of mosquito breeding periods annually is problematic as weather patterns and site conditions (temperature, rainfall, tidal regimes, hydroperiod, etc.), species of vector, time of year, and ease of access all play an important role in determining surveillance patterns, frequency of site visits, and time spent on the site. Frequency and duration of visits will vary and must vary in order to properly and effectively implement IPM principles and integrated vector management practices. Vector control is by its very nature an adaptive integrated ecosystem management process.

There are times when many large areas are flooded at the same time, and the limitation of time and staff may require that they access known historical mosquito breeding sites with ATVs to facilitate timely monitoring and effective least toxic treatment if mosquito production is found. There is a narrow time window for many of the materials the District uses to effectively manage vectors (i.e., Bti and Bs work on immatures, typically first through early fourth instar, a, stage of larval development before metamorphosis into pupae; methoprene works on larvae only and certain instars depending on formulation, etc.). Other factors such as weather conditions, temperature (ambient and water), access issues, and limited staffing necessitate the occasional use of methods of access other than walking for monitoring and treatment. Without this approach, the District is relegated to adulticiding large areas (to a much greater extent than at present), a method that is least desired by the District and the public that it serves.

The PEIR has specific BMPs to protect the salt marsh harvest mouse (C1 through C8) and Ridgeway's rail (D1 through D8). The latter would also protect the California black rail. The impact analysis in the Draft PEIR relied on these measures to reach the preparers' determination that surveillance activities would have a less-than-significant impact on special-status species and their habitats.

Response 8

CDFW cites a concern regarding the potential for disturbance in tidal marsh habitat for salt marsh harvest mouse. MSMVCD engages in the following BMPs to avoid or minimize disturbance:

> When working in state or federally managed wildlife refuges, the District informs and/or coordinates its surveillance (and treatment) activities with the appropriate resource agency staff to minimize impacts (BMPs A1 and A2).

> District staff receives training from USFWS and CDFW biologists regarding special-status species (BMP A4) and uses existing access routes whenever available (BMP A3).

> Most of the other BMPs cited in Table 2-6 and included as part of the project minimize impacts on special-status species or their habitats in areas where they are likely to occur. These BMPs are implemented in all areas where special-status species have the potential to occur, not just the wildlife refuges/management areas.

> BMPs B1 through B6, C1 through C8, D1 through D8, and E1 through E4 were specifically developed to avoid impacts on tidal marshes and associated special-status species including Ridgway's rail and salt marsh harvest mouse. These measures were developed in cooperation with regulatory agency staff and based on the latest USACE permit requirements.

CDFW recommends the District only remove salt marsh vegetation using hand tools (note, this activity is part of the Vegetation Management Alternative, not Surveillance).

> The District already implements this recommendation (see BMPs C5, D3, E4, F2).

> Pickleweed is typically removed from small order channels and ditches to facilitate access for sampling, improve water circulation, and reduce use of pesticides. This work is typically done with hand tools and is performed infrequently and in line with permitting from state and federal agencies. The District does use heavy equipment at times for larger ditch clearing work, which does entail pickleweed removal. CDFW has the opportunity to review these projects prior to execution.

> In addition, vegetation removal within tidal marshes is often planned and performed cooperatively with CDFW or USFWS staff to address areas that have drainage issues and known sources of mosquito production. These agencies are typically in favor of this work because, of its benefits to special-status species habitat, such as the salt marsh harvest mouse and Ridgeway's rail.

> It is the District's understanding that CDFW staff use vehicles to travel out near to a desired site and then walk in from where the vehicle was parked. District staff essentially do the same thing, whenever

possible and reasonable. Thus the District's ongoing occasional use of vehicles is consistent with ongoing wildlife area management activities and would not represent a substantial adverse change that is reasonably likely to have a significant impact on protected species or their habitat.

When it is necessary to move through salt marsh habitat using vehicles (e.g., it is not always practical to avoid use of motorized equipment for access given the large size of some sites), vehicles are kept on pre-existing access ways as much as practicable (BMPs A3, B2) and are operated in a manner to minimize impacts (BMPs A8, B2).

Response 9

CDFW recommends that the window for vector control activities be shortened from September 1 through January 31 to January 15 in BMPs D3 and G3. However, these BMPs are for physical control and not surveillance to which this comment is directed. This would shorten the work window for physical control by 16 days. The aforementioned BMPs were developed in agreement with permits for mosquito source reduction/physical control work by other regional, state, and federal agencies (USACE, SWRCB, RWQCB, and BCDC). The District will take this CDFW recommendation into consideration for vector control activities other than surveillance if not in conflict with other District permits and when considering other environmental factors such as tides.

Response 10

As noted in Response 3 above and BMP A7, the District uses multiple sources to determine the potential for special-status species, including CTS, to be present in areas where vector control activities are needed. If CTS are known or likely to breed in vernal pools or other water bodies, the District would evaluate the need for these activities and their timing, as well as the likelihood that CTS are present.

For vector control work in vernal pool areas, a low ground pressure vehicle is used to go straight across the connective swale between pools. This is done infrequently and only when there is no alternative option in efficiently navigating a given site. No turns are made in the swales. District staff have had on site meetings with professional biologists to discuss the District's vernal pool, CTS, and vernal pool plant related BMPs. The biologists were in agreement with the BMPs implemented by the District including the infrequent crossing of connective swales. It was readily apparent that cattle grazing at sites containing vernal pools was impacting the grade and condition of the connective swales and was causing far more concern than that of the District's operations. Given the low ground pressure of ATV's utilized by the District and the stipulation that turns would not be made within the swales, the biologist stated that they had no concerns. District staff have also discussed this issue with the vernal pool mitigation Interagency Review Team and Army Corps of Engineers staff. District staff also met with CDFW biologists at the Region 3 Headquarters and discussed this issue and the vernal pool BMPs implemented by the District, equipment use on sites containing vernal pools, mosquito control in vernal pool habitat and the infrequent need to cross vernal pool connective swales. District staff have discussed the District's operations pertaining to sites with vernal pools over the phone with CDFW staff on several occasions. District staff met with a CDFW Biologist in the field on March 9, 2010, at the Swift site to discuss the District's operations on sites containing vernal pools, and the Biologist was in agreement with that protocol for traversing the area. The District demonstrated the use of ATVs and application equipment and the thought process and methods employed in crossing connective swales, if necessary. The CDFW Biologist agreed that crossing the swales is necessary at times and if done carefully and in the most strategic locations is not an issue. District management followed up with the CDFW Biologist after the meeting and confirmed CDFW's opinion. The District does not drive vehicles through vernal pools but stays a minimum of approximately 3 feet outside the pool margin. The majority of the time the distance is substantially greater than 3 feet. This protects CTS breeding in the pools as well as state-listed plants associated with these habitats during their growth and blooming period.

See Response 16 below for permitting of take.

Response 11

The District has never conducted aerial applications over vernal pools, and the potential for this to occur in the future is very low because the pools are separated in space, and thus would require precise application just over each pool, which is not an efficient way to work. Aerial application of larvicide by helicopter is regularly conducted over expanses of tidal habitat and freshwater habitat other than vernal pools. The District notifies the land managers when mosquito production is too high or the acreage of the problem area is too great for hand or land-based equipment application. When aerial application is needed, the area to be treated is recorded by GPS and then the pilot uses the GPS data to perform the application.

Response 12

CDFW is concerned about site-specific unknown impacts that could occur under the Physical Control Alternative and wants the District to evaluate potential impacts at each site and provide feasible, foreseeable avoidance, minimization, and mitigation measures in the PEIR. The physical control water circulation activities are covered as a group of related maintenance activities organized by habitat type so that impacts can be determined in the context of habitat conditions. The analysis of physical control activities is for a programmatic EIR because of the large scope of these activities within the two-county Service Area. The District has been performing these minor drainage and circulation modification activities under a USACE source reduction permit and permits from the San Francisco Bay Development Commission and the Water Resources Regional Water Quality Control Board (see Section 2.8.1.4), which contain conditions to avoid substantial adverse environmental effects and the permits have served as the basis for development of several of the BMPs, primarily those under the following categories:

> A. General BMPs

> B. Tidal-Marsh-Specific BMPs

> G. Maintenance / Construction and Repair of Channels, Tide Gates, and Water Structures in Waters of the U.S. and State

The District also had a LSAA with CDFW (CDFW 2010) that covered work in habitats under CDFW jurisdiction under Section 1600 of the Fish and Game Code at 97 sites in Sonoma and Marin Counties. The 2010 LSAA listed 59 sites in Sonoma County and 28 sites in Marin County, mostly riparian zones/creeks, seasonal low areas, drainage ditches, wetlands, and ponds. This LSAA was amended in 2012 and 2013 to add an additional 10 sites. These sites represent areas of active mosquito surveillance and limited vegetation removal. The LSAA covers maintenance of access into riparian zones, and beds and basins of creeks, seasonal depressions and low areas, seasonal wetlands, ponds, and storm water drainage ditches to perform mosquito surveillance, mosquito-borne disease surveillance, and mosquito control at all 97 sites. Covered project activities include:

> Minor trimming of vegetation (generally 3 inches diameter or less)

> Trimming of overhanging limbs and brush

> Removal of small sections of downed trees or limbs within channels

> Mowing

The permit contains specific avoidance and minimization measures and requires written notification of maintenance projects completed annually with reports due by June 30. It also has requirements that inform the BMPs. Permit requirements state that activities are to be conducted from October 1 through April 30, and the District attempts to complete the work prior to the onset of seasonal rainfall. (CDFW 2010). The LSAA expired December 31, 2014, and will be renewed. A description of this LSAA will be added to the PEIR Section 2.8.1**.**

In most cases, the District's alterations of both salt and freshwater habitats are for maintenance of these habitats to avoid stagnant water. Section 2.3.2.1 (page 2-11) includes the following text (with typographical errors and omissions corrected).

> "The District performs these physical control activities in accordance with all appropriate environmental regulations (e.g., wetland fill and dredge permits, endangered species review, water quality review, streambed alteration permits, see Section 2.~~7~~8), and in a manner that generally maintains or improves habitat values for desirable species. Major physical control activities or projects (beyond the scope of the District's 5-year regional wetlands permits with the United States Army Corps of Engineers (USACE), San Francisco Bay Regional Water Quality Control Board (RWQCB), State Water Resources Control Board (SWRCB), and San Francisco Bay Conservation and Development Commission (BCDC)) are not addressed under this PEIR (because they are not known at this time). Minor physical control activities (covered by the regional wetlands permits) are addressed in this PEIR. They vary substantially from year to year, but typically consist of up to 10,000 linear feet of ditch maintenance. Under the regional permits, the District's work plans are reviewed annually by trustee and other responsible agencies prior to initiation of the planned work. USACE, USFWS, CDFW, and other responsible agencies can inspect documentation of proposed and completed work.
>
> "The District may request/require landowners and stewards to maintain and clear debris from drainage channels and waterways; excavate built-up spoil material; remove water from tires and other urban containers; cut, trim, mow, and harvest aquatic and riparian plants (but not including any mature trees, special-status plant species[1], or sensitive habitat areas); and perform minor trenching and ditching. The District may provide guidance for mosquito abatement activities to landowners and stewards. However, it will be the responsibility of the landowner to determine and comply with all legal requirements necessary to perform the activity. District policy is that with every recommendation, the District also makes it clear to the landowner the requirement for consultation with resource agencies and acquisition of permits that may be needed prior to commencement of any work." (page 2-11)

Various methods of physical control are included in the Program. These include removing sediments from water circulation ditches, maintenance of water control structures, and removal of debris in natural channels, among other measures. As stated in the PEIR, physical control is considered the most effective mosquito control technique because it provides a long-term solution by reducing or eliminating mosquito developmental sites and ultimately reduces and potentially eliminates the need for chemical applications. Precise impacts cannot be determined at this time due to the programmatic nature of this analysis. Specific sites where these activities occur have not been defined at this time. However, BMPs include measures to ensure that wetlands and riparian habitat are protected and that permit requirements are met (see BMPs A7, F1, F3, G1, G9, and G12). In addition, BMP G2 requires annual work plans that provide details on proposed work for the upcoming season. The work plans provide wetland delineations and vegetation impact areas as well as maps. Agencies including the USACE, USFWS, NMFS, CDFW, BCDC, and RWQCB are given the opportunity to comment on the work plan. Together the BMPs provide specific performance criteria for work performed in sensitive habitats that, along with the requirements to obtain necessary permits from agencies with regulatory responsibility over natural resources and comply with permit conditions, provide sufficient assurance that District activities will not have a substantial adverse impact on wetlands and riparian habitat.

[1] Special-status species are those that are listed as endangered, threatened or candidate species under the federal Endangered Species Act, endangered or threatened under the California Endangered Species Act, or listed as species of special concern by the State of California.

The title of Best Management Practices, Section G has been changed to “Maintenance/Construction and Repair of Tide Gates and Water Structures in Waters of the US and State.” Also in BMP G9, the second sentence is changed to read “No discharge of unsuitable material (e.g., trash) will be made into waters of the United States or State of California.”

Response 13

Concerning CDFW’s request that “all future landscape modifications under the Physical Control Alternative should be independently analyzed under separate CEQA review,” the District maintains that this is not necessary. The minor modifications covered herein as a group of related activities are the “project” requiring various permits as explained under Response 12. If each minor alteration were evaluated independently under CEQA, then the context in which they occur would be lost. Some commenters could complain that the “project” was being separated into smaller pieces to avoid showing impacts, called “piecemealing.” As noted, the District will need to coordinate with CDFW on the extension of its LSAA. This PEIR will inform the permitting process and the agencies involved, including CDFW. If a particular site poses a special concern to CDFW, the District will consult with CDFW biologists on how to proceed and whether any additional analysis is warranted.

Response 14

Removal of mosquito larvae through vector control activities is unlikely to affect CTS larval food sources, since the mosquito larvae and pupae do not constitute an important part of their diet, nor the diet of their primary prey. CTS larvae consume a variety of food items including aquatic invertebrates, primarily small crustaceans, as well as Pacific chorus frog tadpoles and snails (Anderson 1968). After hatching, larvae feed primarily on small invertebrates, switching to larger prey (tadpoles and snails) within about two weeks to support their rapid growth. Mosquito larvae and pupae were not found in the stomach contents of CTS larvae in this study, which was conducted in Santa Cruz County, California.

The cladocera (crustaceans) consumed by CTS larvae are filter feeders that feed primarily on phytoplankton, algae, bacteria, and dead plant material (Murry Darling Freshwater Research Centre 2013). Chironomid larvae are opportunistic omnivores that feed on algae, fungi, pollen, leaf and wood fragments, detritus, animal remains, and silt (Henriquez-Oliveira et al. 2003).

Chorus frog tadpoles feed on green algae, blue-green algae, bacteria, diatoms, protozoa, and organic and inorganic debris. They feed primarily on the bottom of aquatic habitats but can feed at the surface when pollen or diatoms are present (Rorabaugh and Lannoo 2016).

The mosquito larvicides the District uses in vernal pool habitats (e.g., *Bacillus thuringiensis* and *Bacillus sphaericus)* have been shown to be very specific to mosquito larvae, and nontarget impacts are minimal to nonexistent for invertebrates or amphibians (Glare and O’Callaghan 1998). Lawler and Dritz (2013) report that the larvicide spinosad is an effective treatment for mosquito larvae at recommended doses but that at doses greater than those that kill mosquito larvae, it can kill mayflies and some other nontarget insects that may serve as prey items for other species. Therefore, Lawler and Dritz (2013) indicate that doses that are effective against mosquito larvae are below levels that would even marginally impact nontarget insect populations. If an impact occurs, it would be inconsequential. Even if the spinosad application for mosquito control impacts some individuals in a nontarget insect population, these nontarget populations are reproductively robust and the time to replace the individuals in the population is relatively short (Emlen 1989).

The District does consider mosquito abundance and the mosquito species present in vernal pools prior to larvicide treatment. Mosquito control in vernal pool habitats is indeed surveillance driven and involves significant time and effort by District staff. Constructed vernal pools in the Santa Rosa Plain produce substantial populations of the western encephalitis mosquito (*Culex tarsalis*). *Culex tarsalis* is the primary vector of West Nile virus in California. The vernal pool habitats in the Santa Rosa Plain are in close

proximity to homes and cities that are well within flight range of this mosquito species. Prevention, and early detection of potential health risks through surveillance, followed by treatment, according to IVM principles, is key to protecting the health of both vernal pool species and surrounding communities.

Response 15

CDFW requests that the District modify BMP G2 to include a meeting with CDFW annually, prior to the onset of the rainy season to discuss numerous issues. BMP G2 specifically pertains to submission of project proposals relevant to physical control and the maintenance, construction, and repair of water control structures and tide gates as outlined in the District's previous nationwide permit for mosquito source reduction. The issues that CDFW has suggested for discussion pertain to potential pathogen spread, weed abatement, mosquito control, and District access to CDFW properties. The District agrees that an annual meeting would be appropriate to discuss the aforementioned topics and such a meeting is now also necessary to discuss the implementation of Fish and Game Code Section 1506 (mentioned on page 1-7 of the PEIR). The District can work with CDFW on the scheduling of meetings. The District currently does meet with CDFW staff to discuss several of the topics mentioned and for many years has provided a substantial amount of site access and treatment data attached to quarterly billing statements submitted to CDFW. The District and CDFW can discuss the specifics of further reporting at upcoming meetings, as appropriate.

Response 16

Concerning the comments that a CESA Permit is required for projects that could result in the "take" of any state-listed species, and a CESA Permit being subject to CEQA documentation, the following response is provided.

This Programmatic EIR was not written with the intent of meeting detailed data/site-specific requirements for a CESA permit. The District acknowledges that additional environmental documentation and area specific impact assessments may be required in obtaining permits if necessary, including CESA, ESA, LSAA, and Clean Water Act section 401 and 404 permits. Rather, this PEIR meets CEQA requirements for a Program covering a large area with impact determinations based on thresholds of significance and professional judgment that reflect CEQA's definition of a significant impact – a substantial adverse effect.

Take is defined in Section 86 of the Fish and Game Code as "hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill." Based on the District BMPs and additional mitigation measures included in the Draft PEIR, with modifications based on agency consultations and public comments for this responses to comments component of MSMVCD's Final PEIR, and based on its long history and extensive experience implementing the Program activities, the District does not anticipate that its actions will result in take of any listed species.

Vector control actions could result in some individuals potentially being unintentionally harassed (i.e., prompted or forced to temporarily leave its specific location). The potential for such inadvertent disturbance occurs any time humans come into proximity of protected species, including through visits to or management of wildlife refuges. However, it is not reasonably foreseeable that such disturbance would constitute harm that actually kills or injures fish or wildlife. The potential for impacts associated with maintenance of drainage ditches and limited vegetation management can be avoided or minimized using the BMPs identified in the PEIR. It should also be noted that using chemical treatment is an option if physical control methods were to be avoided. Furthermore, all activity at the refuges to control mosquitoes is coordinated with the refuge manager/staff; and the need to address mosquito populations and breeding habitat at state/county/city parks and lands is also coordinated with the staff of these areas, which further minimizes the potential for any direct or indirect take of species.

Obtaining a CESA permit is not required but would provide the District with immunity from take liability under CESA, if take were reasonably foreseeable. Based on the evidence and analysis in this PEIR, and the District's extensive experience implementing the Program, the District does not believe that it is reasonably foreseeable that any of the Program activities will result in take as defined under CESA. To date, none of the vector control districts involved in the SF Bay Area and Salinas Valley have been required to obtain a CESA permit for ongoing vector management activities. In 2015, CDFW determined that CDPH, and the districts operating under a valid Cooperative Agreement with CDPH to conduct surveillance, prevention, or control of vectors and vector- borne diseases, are not required to obtain a scientific collecting permit (SCP) under Fish and Game Code Sections 1002, 4005(e), and 4011. A SCP is required for any scientific study conducted by or in collaboration with CDPH or local agencies that is not routine surveillance and control activities and includes take of animals or plants (CDFW 2015). MSMVCD has a Cooperative Agreement with CDPH that is described in Section 1.1.3.1.1 of the Draft PEIR and renewed annually.

If it is determined that a CESA permit is required for any Program activities, the PEIR will be revisited as indicated in Section 1.8. The need for any project-level CEQA review at a particular source control/treatment site would be considered at the time the District applied for a CESA permit, if required.

Response 17

Under the California Fish and Game Code, Lake and Streambed Alteration Agreement (LSAA) requirements apply to any activity that will:

> substantially divert or obstruct the natural flow of any river, stream or lake; or

> substantially change or use any material from the bed, channel, or bank of, any river, stream, or lake; or

> deposit or dispose of debris, waste, or other material containing crumbled, flaked, or ground pavement where it may pass into any river, stream, or lake; and

> substantially adversely affect fish or wildlife.

The District does not engage in large-scale operations affecting lakes and streams (e.g., soil movement, removal of vegetation with branches and stems that exceed 4 inches in diameter, removal of large amounts of vegetation), nor does the District request landowners to engage in such activities. Based on its history of implementing the Program alternatives, the District does not anticipate that its physical control and vegetation management activities will result in diversion or alteration of natural flow or modify the bed, channel, or bank except to improve circulation of water and remove vegetation that creates mosquito breeding habitat, and in no event would any such activities be likely to be "substantial" within the meaning of the Fish and Game Code. For example, under surveillance, taking a water sample to check for mosquito larvae would not modify flows or material from the bed, channel, or bank. BMPs G1 through G17 address maintenance activities in channels/water facilities in waters of the US, including management of sidecast spoils in BMP G16. However, the District will confer with CDFW to provide clarifications on Program activities and review CDFW concerns to determine appropriate LSAA coverage as part of its renewal of its existing LSAA. The need for any subsequent project-level CEQA review at a particular source control/treatment site would be considered at the time the District applied for extension of its LSAA permit.

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Mr. Phil Smith
Marin/Sonoma Mosquito
And Vector Control District
595 Helman Lane
Cotati, CA 94931

Marin/Sonoma Mosquito and Vector Control – Draft Environmental Impact Report (DEIR)

Dear Mr. Smith:

Thank you for including the California Department of Transportation (Caltrans) in the environmental review process for the Marin/Sonoma Mosquito and Vector Control District Integrated Vector Management Program. Our comments are based on the DEIR.

Project Understanding

The proposed program is a management strategy intended to control vector-borne diseases in Marin and Sonoma County by targeting mosquitos, rats, yellow jackets, and ticks. The Marin/Sonoma Mosquito and Vector Control District has proposed several program alternatives which include: surveillance, physical control, vegetation management, biological control (pathogens and predators), chemical control and nonchemical control/trapping. It is noted in the DEIR that the program will include a combination of these vector management strategies.

Biological Impacts

Areas subject to physical, chemical or biological control that are within Caltrans Right of Way (ROW), or Caltrans mitigation sites may contain sensitive biological resources (e.g. wetlands, listed-species habitat, waters, etc.). These resources are regulated by Federal and State agencies. The activities listed may require consultation with the U.S. Fish and Wildlife Service (USFWS)/ National Marine Fisheries Service (NMFS), and may require permits from the U.S. Army Corps of Engineers (USACOE), Regional Water Quality Control Board (RWQCB) and/or California Department of Fish and Wildlife (CDFW). Caltrans Office of Biological Science and Permits recommends that the Marin/Sonoma Mosquito Vector Control District provide environmental clearances for these activities prior to performing them within Caltrans ROW where biological resources may be impacted. 1

"Provide a safe, sustainable, integrated and efficient transportation system to enhance California's economy and livability"

S-DOT

Mitigation Responsibility
As the lead agency, the Marin/Sonoma Mosquito Vector Control District is responsible for all project mitigation. Where mitigation is a condition of approval, CEQA requires a Mitigation Monitoring and Reporting Program (MMRP). Required information is listed below. Further information on the MMRP is available on the following website:
http://www.dot.ca.gov/hq/tpp/offices/ocp/igr_ceqa.html.

2

- Lead Agency contact name, address, and telephone number,
- Location, type and implementation schedule for each mitigation measure, and
- Signed and dated certification that the mitigation has been implemented

Should you have any questions regarding this letter or require additional information, please contact Cole Iwamasa at (510) 286-5534 or by email at: cole.iwamasa@dot.ca.gov.

Sincerely,

PATRICIA MAURICE
District Branch Chief
Local Development - Intergovernmental Review

c: State Clearinghouse

"Provide a safe, sustainable, integrated and efficient transportation system to enhance California's economy and livability"

S-DOT

Mr. Phil Smith, Marin/Sonoma
Mosquito and Vector Control District
September 16, 2015
Page 3

bcc:PMaurice/CIwamasa/ChronFile/FMalamod-Roam

"Provide a safe, sustainable, integrated and efficient transportation system to enhance California's economy and livability"

Comment Letter S-DOT — California Department of Transportation

Patricia Maurice, District Branch Chief
September 16, 2015

Response 1

The agency requests that the District provide environmental clearances for vector control activities within California Department of Transportation's (Caltrans) right-of-way (ROW) or at Caltrans mitigation sites.

For work on State of California lands and riparian zones, wetlands, or other sensitive habitats, the District coordinates, reviews activities, communicates, and often collaborates with several agencies including the USFWS, CDFW, Marin and Sonoma County agencies, municipalities, and property owners of Marin and Sonoma counties. District staff has long standing cooperative, collaborative relationships with federal, state, and local agencies. Section 2.8 of the PEIR covers the District's permits with other agencies (pages 2-52 through 2-54). The District is aware and understands that new sources of mosquito production found within the Caltrans ROW may contain sensitive habitat and resources and consultation with the appropriate regulatory agencies may be necessary.

As indicated in the Draft PEIR, physical control/source reduction is an important component of the District's Integrated Vector Management Program. This component of the program includes working with property owners and land managers to minimize the potential for mosquito production and vector-borne disease transmission. The California Health and Safety Code (Section 2000 et seq.) clearly delineates property owner responsibility relative to mosquito and vector abatement. It is of the utmost importance that Caltrans properly manages and maintains (e.g., both grade and vegetation) the function of water conveyance features (e.g., roadside water conveyance channels) to minimize and potentially prevent mosquito production and the need for mosquito control operations. The District is aware that Caltrans has worked closely with the California Department of Public Health with regard to identifying the potential for mosquito production and properly maintaining water conveyance features in Caltrans ROWs.

An example of an opportunity for prudent mosquito source reduction exists in the Caltrans ROW east of Black Point and immediately east of the juncture of Atherton Avenue and Highway 37 in Marin County. The ROW is on the immediate north side of Highway 37. District staff have met previously with Caltrans staff on January 7, 2013, to discuss this point. During that January 7, 2013, meeting and in follow up correspondence in January 2014, we explained a significant mosquito control and water conveyance issue within the Caltrans ROW immediately north of Highway 37 and east of Black Point in Marin County. We have yet to receive any feedback regarding any potential solutions to this problem area.

We suggest identifying vector control problem areas with your staff for Caltrans to manage and maintain. As the landowner/land manager, Caltrans should obtain the necessary permits from CDFW for this maintenance activity as part of its overall maintenance program for state ROWs within Marin and Sonoma counties. For Caltrans mitigation areas, we can review those with staff as well. However, State mitigation areas also need to be maintained to avoid becoming mosquito-breeding habitat. If state-owned lands are not maintained and vector problems arise, the District will need to treat the problem expeditiously and not wait for mosquito larvae or pupae to complete their life cycle.

Section 1.1.3 of the PEIR identifies a number of legislative and regulatory actions that form the basis for the District's authority to engage in vector control. The District is a regulatory agency formed pursuant to California Health and Safety Code Section 2000 et seq. In enacting that law the California Legislature recognized the importance to public health and the economy of proactive management of vectors. Furthermore, due to its public health mission, the California Department of Pesticide Regulation's (CDPR's) Pesticide Regulatory Program provides special procedures for vector control agencies that operate under a Cooperative Agreement with the CDPH. The District operates under a Cooperative Agreement with CDPH (CDPH and MARIN/SONOMA 2015) that is renewed annually. The application of

pesticides by vector control agencies is regulated by a special and unique arrangement among the CDPH, CDPR, and County Agricultural Commissioners.

Response 2

The information on mitigation responsibility is understood. As required by CEQA, the District will prepare a Mitigation Monitoring Program (MMP) for our Board to consider prior to Program approval.

Additional References

California Department of Public Health (CDPH) and Marin/Sonoma Mosquito and Vector Control District (MSMVCD). 2014. Cooperative Agreement. November 21.

California Department of Public Health (CDPH) and Marin/Sonoma Mosquito and Vector Control District (MSMVCD). 2015. Cooperative Agreement. October 19.

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S-DPR

State of California • Natural Resources Agency
DEPARTMENT OF PARKS AND RECREATION
Bay Area District
845 Casa Grande Road
Petaluma, CA 94954

Edmund G. Brown Jr., *Governor*
Lisa Ann L. Mangat, *Director*

Marin/Sonoma Mosquito & Vector Control District
Rec'd 10-15-2015

October 12, 2015

Marin/Sonoma Mosquito & Vector Control District
595 Helman Land,
Cotati, CA 94931

Subject: Draft Programmatic Environmental Impact Report, SCH #2012052066

California State Parks, Bay Area District, is providing the following comments to the draft EIR referenced above.

1. State Parks supports any surveillance work performed by Vector Control District within California State Park jurisdictions. Currently, scientific collection permits are issued for other Vector Control Districts to enter State Park lands for these activities. The permits allow us to obtain the data collected during their surveys while requiring review of their methodologies and notification of request for access. Obtaining a scientific collection permit prior to continuing surveillance program within any State Park jurisdiction is required. 1

2. State Park policy strictly dictates pest, animal, and insect control, as well as vegetation management within State Parks. In addition, terrestrial and aquatic habitat contain native, rare, State and federal endangered invertebrates, amphibian, and reptile species whose protection is codified by Operations Policy, Mission, as well as State and federal laws. It should be made clear that any pesticide use for vector control, herbicide use for vegetation management, or use of biological control agents, as well as their authority to enter State Park jurisdictions for such purposes, shall be reviewed and approved by State Parks. State Parks will strive to work with Vector Control Districts to provide programmatic approval for maintenance activities. Factors which will be weighed during approval evaluation include level of risk from the mosquito/other pest, species and habitats in the area, public interface, and current scientific data. 2

If you have any questions or comments, please contact Christina Freeman, Environmental Scientist, at 707-769-5652 x209.

Sincerely,

Roy McNamee, Environmental Coordinator (Acting)
Bay Area District

Comment Letter S-DPR California Department of Parks and Recreation

Roy McNamee, Environmental Coordinator (Acting)
October 12, 2015

Response 1

The commenter states support for the District's vector control related work and discussed the function of State Park issued Scientific Collecting Permits. The District has had, and continues to have, excellent communication and a collaborative working relationship with the Bay Area District of the California Department of Parks and Recreation (State Parks). The District is in regular communication with State Parks staff regarding mosquito surveillance and control and for many years has obtained scientific collecting permits (SCPs) for tick collection. As the comment letter requests, District staff provides data and reports annually regarding the District's tick collection and tick-borne disease testing work. The District will continue to foster the working relationships currently in place and obtain SCPs as necessary. The District has a cooperative agreement with the California Department of Public Health (CDPH) explained in the PEIR Section 1.1.3.1.1. Also see Response 2 below on this agreement and SCPs.

Response 2

As indicated in Response 1, the District works closely with State Parks staff regarding the District's operations on State Park lands. The District assists and responds to service requests from State Park staff to minimize mosquito populations, discomfort, and potential injury to State Park staff and visitors.

The District will also continue to communicate with State Parks staff regarding special-status species and their habitats on State Park lands. The commenter's request for State Parks approval for District access and operations has been noted. For the commenter's reference, please see the attached letter from the California Department of Fish and Wildlife to the CDPH regarding the Cooperative Agreements between CDPH and vector control districts and district operations that allow for SCPs. Additionally, it is recommended that the California State Parks Bay Area District review the California Health and Safety Code (CHSC) as it pertains to mosquito and vector control (Division 3, Chapter 1, Article 5, Section 2060 et. al.) with specific reference to property owner responsibilities. Property owner responsibilities regarding mosquito and vector hazards are clearly delineated in the CHSC. The PEIR presents relevant legislative and regulatory actions pertaining to vector control (Section 1.1.3).

It will be very helpful to the District and beneficial to public health for the Bay Area District of California State Parks to manage and maintain facilities (e.g., onsite wastewater management systems, portable toilets etc.), water troughs, water features, and seasonal and tidal wetlands with vector control in mind. This will include vegetation management and maintenance to allow access to water features for mosquito surveillance and control. If the Bay Area District of California State Parks practices mosquito source reduction, then the potential for mosquito production, the need for larval and/or adult mosquito control using chemical treatments, and the potential for mosquito-borne disease transmission to humans, livestock, and wildlife will be minimized. Managing tick habitat immediately adjacent to walking trails and posting informational signs can significantly reduce the potential for the transmission of tick-borne diseases including Lyme disease.

S-DPR Attachment

State of California – Natural Resources Agency
DEPARTMENT OF FISH AND WILDLIFE
Director's Office
1416 Ninth Street, 12th Floor
Sacramento, CA 95814
www.wildlife.ca.gov

EDMUND G. BROWN JR., Governor
CHARLTON H. BONHAM, Director

April 14, 2015

Karen L. Smith, MD, MPH
Director and State Health Officer
California Department of Public Health
P.O. Box 997377
Mail Stop 0500
Sacramento, CA 95899-7377

Attn: Vicki Kramer, Chief
Vector Borne Disease Section
P.O. Box 997377, MS 7307
Sacramento, CA 95899-7377

Dear Dr. Smith:

Re: Department of Fish and Wildlife (CDFW) scientific collecting permits (SCPs) and other authorities pertaining to vector and vector-borne disease surveillance and control

Recently representatives of California Department of Public Health (CDPH) and entities responsible for monitoring and protecting the public from human health risks posed by mosquitoes, ticks, fleas and other vectors met with Senior Policy Advisor Mark Stopher to discuss various sections of the Fish and Game Code (FGC) and their relationship to your work. It is our understanding that recently, when (CDPH) attempted to renew a state park permit for tick collecting, California Department of Parks & Recreation staff stated they now require permit applicants to provide evidence of SCP for terrestrial invertebrates or alternatively, documentation indicating that such a CDFW permit or approval is not needed for the collections/methods in question. This letter is to clarify CDFW's understanding of statutory authorities for vector surveillance and control, as well as interpretation of the Fish and Game Code, including any requirement for a SCP, in the vector surveillance and control context.

The Health and Safety Code (HSC) evidences clear legislative intent to provide broad authority to entities conducting surveillance, prevention and control of mosquitos and other vectors (e.g., HSC §§ 2001 (c), 2040, 2041, 2047 and 2055). Surveillance and control activities typically involve animals described as "vectors" in the HSC § 2002(k). Mammals that are vectors or reservoirs of vector-borne diseases that are commonly subject to surveillance or control activities are typically "non-game mammals" (F&GC § 4150).

The recent increase in West Nile virus activity, and expanding distribution of invasive mosquito species such as *Aedes aegypti*, emphasize the necessity of on-going surveillance to monitor vectors and disease trends to protect public health. These

Conserving California's Wildlife Since 1870

S-DPR Attachment

activities are usually, though not always, located in proximity to human populations or developments.

We have also reviewed several examples of Cooperative Agreements developed by CDPH, in partnership with the Department of Pesticide Regulation and Agricultural Commissioners, and signed by local vector control agencies. These demonstrate that CDPH maintains a close relationship with local vector control agencies throughout California for the purpose of maintaining a statewide surveillance and control program (HSC § 116110). This relationship includes consultation, technical assistance, and the certification of vector control technicians. The training and certification requirements are enforced through the Cooperative Agreements that CDPH and local agencies renew annually, under the terms and conditions prescribed by CDPH (HSC § 116180(a)). CDPH conducts regular on-site reviews at local agencies for adherence to the terms of the agreements.

FGC § 1002 sets forth CDFW's authority to issue SCPs. In doing so, the section provides that CDFW may issue permits for the take of animals and plants, for scientific, educational or propagation purposes. FGC § 4005(e) and § 4011 exempt the taking of mammals in certain circumstances relating to control of vectors from the prohibition of FGC § 2000.

In consideration of the above, CDFW has determined that CDPH, and entities which are operating under a valid current Cooperative Agreement with CDPH to conduct surveillance, prevention or control of vectors and vector borne diseases:

- Are not conducting science, educational or propagation activities within the scope of FGC § 1002, and a SCP is not required.
- Are exempt from the requirement for a license to trap fur-bearing or nongame mammals pursuant to FGC § 4005(e) and § 4011.
- Do not require a SCP when taking blood samples from birds when those birds are collected for other purposes by individuals who already have a SCP or bird banding permit for that work.
- Do not require any permit from CDFW when collecting or examining vectors (e.g., fleas or ticks) taken from wildlife which were lawfully collected by another entity including, but not limited to, U.S.D.A. Wildlife Services.

A SCP is required for any scientific study conducted by or in collaboration with CDPH or local agencies which is not routine surveillance and control activities and incudes take of animals or plants.

S-DPR Attachment

Karen L. Smith, MD, MPH
Director and State Health Officer
California Department of Public Health
April 14, 2015
Page 3

None of the above is to infer that coordination by vector control agencies with landowners, including CDFW is not necessary. For CDFW lands, it is important for local vector control agencies to coordinate access and actions closely with CDFW to avoid unnecessary conflicts with our operations.

If you have questions, or further coordination on this issue becomes necessary, please contact Senior Policy Advisor Mark Stopher, at 530.225.2275 or at Mark.Stopher@wildlife.ca.gov.

Sincerely,

Charlton H. Bonham
Director

cc: Lisa Mangat, Acting Director
California Department of Parks and Recreation
1416 Ninth Street
Sacramento, CA 95814

ec: California Department of Fish and Wildlife

Dan Yparraguirre, Deputy Director
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S-DPR Attachment

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L-NMWD

Received Tue Oct 6, 2015
late submittal

NORTH MARIN WATER DISTRICT

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October 2, 2015

Philip D. Smith
595 Helman Lane
Cotati, CA 94931

RE: Comments on the Marin/Sonoma Mosquito and Vector Control District Draft Program Environmental Impact Report

Dear Mr. Smith:

North Marin Water District (NMWD) has reviewed the draft PEIR. The water resources section addresses the use of pesticides and herbicides used to control breeding areas for mosquitos. Although the PEIR is thorough in its description of applying these chemicals according to label requirements and applicable state and federal requirements, NMWD does not believe that these measures are sufficient when chemicals with potentially negative impacts on human health could be used where contamination of drinking water sources is possible. Many of the chemicals used by the Marin Sonoma Mosquito and Vector Control District (MSMAVCD) as outlined in the document are regulated contaminants in drinking water. 1

North Marin Water District's goal towards protection of our drinking water sources is to lower the risk of contamination to zero. This goal translates to prohibiting the use of herbicides and pesticides that are regulated in drinking water on lands within the Stafford Lake Watershed. We request that the following conditions be adopted by MSMAVCD for the use of pesticides and herbicides on the Stafford Lake Watershed. 2

1. To completely eliminate the potential for surface water contamination due to runoff or incidental discharge, no pesticides, herbicide, adjuvants, or other chemicals that are regulated contaminants in drinking water shall be used on any part of the Stafford Lake Watershed.
2. When application of any biological or chemical control is indicated by the program and scheduled to take place on the Stafford Lake Watershed, MSMAVCD shall consult with NMWD 5 working days prior to application in order to provide notification and to investigate alternatives.
3. A report of any chemical or biological controls used on the Stafford Lake watershed shall be provided to NMWD at the end of each calendar year. The report should include types of control used, including any biological or chemical components, amounts of chemicals used, and locations of application.

Sincerely,

Chris DeGabriele
General Manager

Cc:
Supervisor Kinsey, 3501 Civic Center Drive Room 329 San Rafael, CA 94903
Supervisor Arnold, 3501 Civic Center Drive Room 329 San Rafael, CA 94903
Krishna Kumar, MMWD GM, 220 Nellen Ave, Corte Madera, CA 94925
Janice Thomas, SWRCB DDW, 50 D Street, Suite 200 Santa Rosa CA 95404

DIRECTORS: JACK BAKER • RICK FRAITES • STEPHEN PETTERLE • DENNIS RODONI • JOHN C. SCHOONOVER
OFFICERS: CHRIS DEGABRIELE, General Manager • KATIE YOUNG, Secretary • DAVID L. BENTLEY, Auditor-Controller • DREW MCINTYRE, Chief Engineer

Comment Letter L-NMWD

North Marin Water District

Chris DeGabriele, General Manager
October 2, 2015

Response 1

The NMWD's concern is with the potential for use of pesticides, herbicides, and adjuvants to impact drinking water supply in Stafford Lake because the commenter believes that product label requirements and applicable state and federal requirements are not sufficient to protect human health from possible contamination from vector control activities. According to the NMWD website (http://www.nmwd.com/about_history_novato.php), Stafford Lake provides approximately 20 percent of the City of Novato's water, lies 4 miles west of downtown Novato, and collects runoff from 8.3 square miles of watershed property located upstream at the upper tributary reaches of Novato Creek. The primary water quality issue from testing conducted by NMWD is contamination from animal feedlots and dairies in the watershed. Water from Stafford Lake is drawn by the intake tower and fed by gravity or by pumping (depending on the lake level) into the treatment plant located just below the dam.

The District has, for at least the past 2 decades, taken an integrated systems approach to mosquito and vector control, utilizing a suite of tools that consists of public education, surveillance, source reduction (e.g., physical control, vegetation management, water management), biological controls, and chemical controls. As stated in PEIR Section 2.3, three core tenets are essential to the success of a sound Integrated Vector Management Program (IVMP).

> First, a proactive approach is necessary to minimize impacts and maximize successful vector management. Elements such as thorough surveillance and a strong public education program make all the difference in reducing potential human vector interactions.

> Second, long-term environmentally based solutions (e.g., water management, reduction of harborage and food resources, exclusion, and enhancement of predators and parasites) are optimal as they reduce the potential pesticide load in the environment as well as other potential long- and short-term impacts.

> Lastly, utilizing the full array of options and tools (public education, surveillance, physical control, biological control, and when necessary chemical control) in an informed and coordinated approach supports the overall goal of an environmentally sensitive vector management program.

Historically, the District has focused on mosquito surveillance, with occasional larvicide treatment (with VectoMax FG) and mosquitofish stocking in cattle troughs and areas of open space in the Stafford Lake watershed. The District has sampled mosquito larvae from the lake associated with undesirable vegetation in the lake. However, no adulticides or herbicides were used in this area.

VectoMax FG is a larvicide mixture of the microbial pesticides Bti and Bs. (Bti and Bs are naturally occurring soil bacteria that produce chemicals that bind to receptor cells present in insects, but not mammals.) The USEPA has determined that these microbial pesticides are essentially nontoxic to humans and do not pose risks to wildlife, nontarget species, or the environment when they are used according to label directions (SWRCB 2014).

Additional surveillance, larvicide treatment, mosquitofish stocking, and occasional yellow jacket control have been needed in areas downstream of Stafford Lake. Previous adulticide applications have not occurred in the vicinity of Stafford Lake or the immediate downstream area. Adulticides have been used in heavily populated areas in Novato and near the Hwy 101 corridor, more than 4 miles downstream of the Stafford Lake area, when needed, such as when West Nile virus activity was identified in the Novato area (e.g., dead birds, positive mosquito pools, and a human case). Because of the distance and downstream location, these adulticide applications had little to no potential to affect the Stafford Lake area.

The District's current or future vector control activities in the Stafford Lake watershed are highly unlikely to result in potential impacts to water quality (see Chapter 9, Water Resources) and human health (see Chapter 7, Human Health), as discussed in the PEIR where potential impacts from all of the chemical treatment methods the District uses (or proposes to use in the future) were evaluated. With the exception of the herbicide glyphosate, none of the active ingredients that the District uses (or proposes to use in the future) are regulated by drinking water standards adopted by the EPA or by California (see SWRCB 2016).

As discussed in the PEIR, impacts to water quality and to human health from vector control activities would be less than significant for the following reasons:

> Most of the vector control activity is for surveillance of mosquito populations within the watershed where District technicians take water samples to look for the number of mosquito larvae present, determine if the numbers are high enough to require intervention, and then determine which alternative treatment method is most appropriate. The specific actions taken in response to current or potential vector activity at a specific place and time depend on factors of vector and pathogen biology, physical and biotic environment, human settlement patterns, local standards, available control methods, and institutional and legal constraints. Surveillance activities are not harmful to the environment, because minimal disruption to habitat and to air quality/greenhouse gas emissions from equipment use occurs as explained in the PEIR (Sections 10.2.3 and 11.2.3).

> The District also responds to occasional service requests from residents within the developed portions of the watershed for biting mosquito or yellow jacket wasp problems. When responding to a service request, technicians engage in educating the property owner on measures to avoid the problem focusing on source control measures and the use of mosquitofish in isolated fountains and ponds. Chemical methods to reduce mosquito breeding habitat or mosquito larvae/adults are a final method to resolve problems with septic tanks and drain fields, waste ponds, and other problem areas where stagnant water accumulates including seasonal wetlands.

> The District's Proposed Program is an IVMP. District policy is to identify those species that are currently vectors, to recommend techniques for their prevention and control, and to anticipate and minimize any new interactions between vectors and humans and domestic animals. The District's IVMP employs integrated pest management (IPM) principles by first determining the species and abundance of mosquitoes/vectors through evaluation of public service requests and field surveys of immature and adult mosquito/vector populations and, then, if the populations exceed treatment guidelines, using the most efficient, effective, and environmentally sensitive means of control. This approach minimizes the need for chemical use.

> Treatment of the lake would not occur unless there was an imminent threat to public health from vector-borne disease. The District does not directly treat drinking water supplies because these supplies do not usually include stagnant areas that encourage algal blooms and mosquito breeding. If such a situation occurred, NMWD would be notified immediately of the problem. No chemical treatment of drinking water supplies would be done without consulting with CDPH.

> The District does not normally engage in vegetation management involving herbicides in the Stafford Lake watershed. Herbicides are used only when physical methods involving vegetation clearance by hand tools or trimmers are not appropriate given site conditions or if assistance in removing invasive plants/noxious weeds is requested of the District by another agency. For example, vegetation control at winery or other wastewater ponds can involve the use of herbicides. The District will not use herbicides at the margins of a drinking water supply including Stafford Lake.

> The evaluations of the impacts to human health from all chemical treatment active ingredients and key adjuvants are contained in Chapter 7, Human Health, and were conducted by technical staff with the appropriate qualifications in toxicology and environmental health. These evaluations are based not only on the assessments of the chemical's toxicity and physical fate and transport contained in the scientific literature, included in the PEIR's Appendix B, Ecological and Human Health Assessment

Report (and supplemented in the PEIR chapters with additional material), but also in consideration of the District's application methods including not just the product label requirements but also the context in which the product is used (i.e., field conditions that impact product persistence or "breakdown" in the environment). Most of the chemicals used by the District break down into nonhazardous materials relatively quickly which minimizes the potential for them to be carried by runoff into the lake. Furthermore, the ultra low volume (ULV) method of fogging or aerosol application for adulticiding assists in this degradation of the active ingredient. For example, Section 9.2.7.2.1 contains the following discussion (page 9-36):

> "Pyrethrins and pyrethroids quickly adsorb to suspended solids in the water column and partition into the sediment. They adsorb strongly to soil surfaces, and are generally considered immobile in soils and, therefore, are unlikely to leach to groundwater (USEPA 2006c). These materials are relatively nontoxic to mammals and birds, but are highly toxic to fish and invertebrates. The major route of degradation is through photolysis in both water and soil. Pyrethrins and pyrethroids may be persistent in environments free of light, and pyrethroids as a class have been implicated in 303(d) listings of sediment toxicity in urban creeks (BASMAA 2013). However, the ULV applications common to mosquito control and the limited use at ground-dwelling yellow jacket wasp nests (that pose an imminent threat to people or to pets) encourage dissipation rather than persistence in the environment."

Another example of how the District has gone beyond the product label requirements to minimize and avoid possible impacts to the environment and human and ecological health are the use of best management practices (BMPs) developed from permit requirements and the experience of other vector control districts. In Chapter 9, Water Resources, the District is using several BMPs as control measures to avoid and minimize impacts to water resources. See Table 9-3 (pages 9-19 – 9-22), a subset of practices in Table 2-6 in Chapter 2). For example, BMP H2 states: "The District will avoid use of surfactants when possible in sites with aquatic nontargets or natural enemies of mosquitoes present such as nymphal damselflies and dragonflies, dytiscids, hydrophilids, corixids, notonectids, and ephydrids. Surfactants are the only tool that can be used with pupae to prevent adult mosquito emergence. The District will use a microbial larvicide (e.g., Bti, Bs), insect growth regulator (e.g., methoprene) instead, or another alternative when possible."

Further support for the conclusions of less-than-significant impacts, and the likelihood of no impact to drinking water supplies consistent with NMWD's policy of zero contamination, is provided in a 2-year monitoring study conducted for the State Water Resources Control Board by the Mosquito and Vector Control Association of California (MVCAC) monitoring coalition to determine whether vector control activities were contributing contaminants to State waters.

The MVCAC monitoring coalition conducted chemical monitoring for adulticides at 61 locations during 19 application events in 2011 to 2012 and coordinated physical monitoring for 136 larvicide application events in 2012. Samples were collected from agricultural, urban, and wetland environmental settings in both northern and southern California. The adulticides evaluated included pyrethrin, permethrin, sumithrin, prallethrin, etofenprox, naled, malathion, and the synergist piperonyl butoxide. This monitoring study (MVCAC 2013) was conducted in accordance with the Statewide NPDES Vector Control Permit and had the following results:

> 1 out of 136 visual observations showed a difference between background and post-event samples;

> 108 physical monitoring samples showed no difference between background and post-event samples; and

> 6 out of 112 samples exceeded the receiving water monitoring limitation or triggers.

The report concluded that there was no significant impact to beneficial uses of receiving waters due to application of vector control pesticides in accordance with approved application rates. This is consistent

with the primary mandate for vector control districts of protecting public health by reducing vector-borne diseases from mosquitoes and other vectors.

The State Water Resources Control Board evaluated the results of this study (MVCAC 2013) and a concurrent toxicity study conducted by researchers from UC Davis (Philips et al. 2013) and concluded that based on the monitoring data, the application of pesticides in accordance with approved application rates does not impact beneficial uses of receiving waters (SWRCB 2014). Therefore, the monitoring and reporting program for the Vector Control Permit was amended in March 2014 to limit the required monitoring to visual observations, monitoring and reporting of pesticide application rates, and reporting of noncompliant applications (SWRCB 2014).

Response 2

The comment states that the NMWD has a goal of lowering the risk of contamination to drinking water sources to zero and that the use of herbicides and pesticides that are regulated in drinking water are prohibited by NMWD on lands within the Stafford Lake Watershed in order to prevent runoff or incidental discharge. NMWD requests that the District to consult with NMWD 5 working days prior to an application of any biological or chemical control product. Furthermore, NMWD asks that a report each year of materials used in the watershed be provided.

The concern about pesticides' active ingredients reaching the lake from runoff or incidental discharge is addressed in Response 1 above. The District does not directly treat Stafford Lake, but if chemical treatment were needed in the event of a severe threat to public health, both NMWD and CDPH would be notified of the severity of the problem and the proposed chemical to be used. Most of the District's work in the watershed is to conduct surveillance and to respond to public service requests from farmers and residents within the watershed. Between surveillance activity and requests for service, when a vector problem is identified that requires a chemical treatment method, consistent with the District's IVM policies and procedures explained in Response 1, then the District must respond quickly depending on the stage of vector development. The 5 working day notification requirement described in the comment does not reflect the breeding cycle of several mosquito species and the environmental conditions that may speed up this life cycle. The public education and physical control activities to minimize mosquito-breeding habitat are the best methods to minimize the development of a mosquito population density that then requires chemical control, but chemical control cannot be eliminated from the District's IVMP in order to protect the public from vector-borne disease.

NMWD is directed to review PEIR Section 1.1.3, Legislative and Regulatory Actions (pages 1-5 through 1-8), for regulations governing the District's vector control activities. The Legislature granted the District broad powers to address the threat to public health and the economy posed by vectors. State law charges the District with the authority and responsibility to take all necessary or proper steps for the control of mosquitoes and other vectors in the District and specified its duties pursuant to California Health and Safety Code Sections 2040-2045. In accordance with California Health and Safety Code Section 2053, the District may:

> "(b) Subject to the limitations of the United States Constitution and the California Constitution, employees of a district may enter any property, either within the district or property that is located outside the district from which vectors may enter the district, without hindrance or notice for any of the following purposes:
>
> (1) Inspect the property to determine the presence of vectors or public nuisances.
>
> (2) Abate public nuisances pursuant to this chapter, either directly or by giving notice to the property owner to abate the public nuisance.
>
> (3) Determine if a notice to abate public nuisance has been complied with.

(4) Control vectors and treat property with appropriate physical, chemical, or biological control measures." (page 1-7)

As explained in PEIR Section 1.1.3.1.1:

> "Due to their public health mission, the California Department of Pesticide Regulation's (CDPR's) Pesticide Regulatory Program provides special procedures for vector control agencies that operate under a Cooperative Agreement with the CDPH. The application of pesticides by vector control agencies is regulated by a special and unique arrangement among the CDPH, CDPR, and County Agricultural Commissioners. CDPR does not directly regulate vector control agencies. CDPH provides regulatory oversight for vector control agencies that are signatory to the Cooperative Agreement. Signatories to the agreement use only pesticides listed by CDPH, maintain pesticide use reports, and ensure that pesticide use does not result in harmful residues on agricultural products. The District maintains a cooperative agreement with CDPH (CDPH and MSMVCD 2014). Its employees are certified by CDPH as vector control technicians, which help to ensure that employees are adequately trained regarding safe and proper vector control techniques including the handling and use of pesticides and compliance with laws and regulations relating to vector control and environmental protection." (page 1-7)

Concerning the District's cooperative agreement with CDPH: Section 3CCR 6620 Vector Control Exemption exempts cooperating agencies from 3CCR 6614 (b)(1) (Protection of Persons, Animals, and Property), 6616 (Consent to Apply), and 6618 (Notice). Therefore, cooperating agencies may apply pesticides registered for the purpose of vector control in residential areas even though there may be a reasonable possibility of contamination to nontarget persons or property. In addition, cooperating agencies are not required to get property owner consent or provide notification to a property operator prior to a pesticide application. These exemptions are a most important benefit provided to vector control agencies that are bound by the cooperative agreement. They reflect the general understanding that vector control operations protect public health and that **rapid control or suppression of vectors over wide geographic areas is essential to achieve this protection**. Cooperating agencies have neither the time nor the resources to provide notice or acquire consent prior to the application of a public health pesticide except for the District's public notification decision on noise generating applications affecting residential areas, as provided in BMP A12, which are most often aerial applications using helicopters. This type of application has occurred in relation to the wildlife refuges at San Pablo Bay and along the Petaluma River in southern Sonoma County, but not at Stafford Lake.

However, to further IVMP principles and use of nonchemical methods first, the District recommends a meeting with NMWD staff to review the lake and potential problem areas within the watershed and discuss source control measures and the other nonchemical alternatives under the IVMP. There is some undesirable vegetation fostering mosquito breeding at the lake, and we recommend that nonchemical vegetation management be performed. The District is ready to inform a designated staff person of the types of vector habitat problems that require proactive nonchemical treatment. For areas that require chemical treatment, the District will advise NMWD about what products are determined appropriate for use based on the mosquito's stage of development.

Reports of chemical use are provided monthly to the County Agricultural Commissioners. The problem is creating a database that allows for aggregating the daily reports to the Stafford Lake watershed. We can discuss the most feasible method for giving NMWD pertinent information at the meeting with your staff. It should be recognized that there are developed areas within the watershed where private property owners may use pesticides, and these uses could not feasibly be quantified. However, the District's public education activities and materials on how to avoid vector problems are consistent with the NMWD's efforts to protect water supplies from improper use of insecticides and herbicides available for private use.

Additional References

California State Water Resources Control Board (SWRCB). 2014. State Water Resources Control Board Order WQ 2014-0106-DWQ Amending State Water Resources Control Board Water Quality Order 2011-0002-DWQ (as Amended By Orders 2012-0003-DWQ and 2014-0038-EXEC), General Permit No. Cag 990004, Statewide National Pollutant Discharge Elimination System (NPDES) Permit For Biological And Residual Pesticide Discharges To Waters Of The United States From Vector Control Applications. July 2. Available online at http://www.waterboards.ca.gov/board_decisions/adopted_orders/water_quality/2014/wqo2014_0106_dwq_redline.pdf.

California State Water Resources Control Board (SWRCB). 2016. MCL Review in Response to PHGs. Available online at http://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/MCLReview2016.shtml.

Mosquito and Vector Control Association of California NPDES Permit Coalition. 2013. MVCAC NPDES Permit Coalition 2011/2012 Annual Report, NPDES Vector Control Permit (Order No. 2012-0003-DWQ). February 22. Available online at http://www.waterboards.ca.gov/water_issues/programs/npdes/pesticides/docs/vectorcontrol/mvcac_2012.pdf.

Phillips, B.M, B.S. Anderson, J.P. Voorhees, K. Siegler, L. Jennings, M. Peterson, R.S. Tjeerdema, D. Denton, P. TenBrook, K. Larsen, and P. Isorena. 2013. General Pesticide Permit Toxicity Study: Monitoring Aquatic Toxicity of Spray Pesticides to Freshwater Organisms. Draft Final Report. Prepared by University of California, Davis, Department of Environmental Toxicology, United States Environmental Protection Agency, and California State Water Resources Control Board for California State Water Resources Control Board, Agreement Number 10-102-270. July. Available online at http://www.waterboards.ca.gov/water_issues/programs/npdes/pesticides/docs/vectorcontrol/vcp_tox_study_draft_final_july2013.pdf.

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O-MAS

Marin Audubon Society

P.O. Box 599 | Mill Valley, CA 94942-0599 | marinaudubon.org

September 29, 2015

Philip Smith, District Manager
Marin Sonoma Mosquito and Vector Control District
595 Helman Lane
Cotati, CA 94931

RE: DRAFT PROGRAMMATIC ENVIRONMENTAL IMPACT REPORT

Dear Mr. Smith:

The Marin Audubon Society appreciates the opportunity to comment on the Mosquito Abatement District's (District) Draft EIR. Our comments focus on the impacts to biological resources. Our interest are related to impacts but also specifically to wetland conditions and District activities on our properties.

Marin Audubon Society has special interest in the District's programs, activities and the potential impacts of its activities. MAS also has a long relationship with the District because we own approximately 500 acres which we purchased because they support wetlands and we actively work to protect and enhance them as wetland habitat. We also are experienced with what the District does and are contacted fairly regularly for treatment of our properties in north Marin. There are other properties we own that we are not certain the District treats. 1

In a number of places, the DEIR reports that it is the Districts' practice to coordinate and communicate with agencies in undertaking their work. It also mentions that property owners are consulted and that this is stated in BMP's. We could find no BMP that reference coordinating with non-agency property owners. Because we own tidal or seasonal wetlands and wish to maintain them as beneficial habitat, we would like the assurance that the District is required, through a BMP, to contact and coordinate with property owners, such as ourselves, even through these owners may not be agencies. Please create a BMP that commits to coordination with non-agency/government property owners. 2

The DEIR mentions the Migratory Bird Treaty Act, Bald and Golden Protection Act as background but it does not address potential impacts to species protected by these laws. Species covered by these laws include shorebirds, waterfowl, red-tailed hawks, red-shouldered hawks, American kestrel and other raptors, migratory songbirds, waterfowl and shorebirds. In particular migratory waterfowl and shorebirds would likely be impacted. Discuss the potential impact of the loss of invertebrates on marsh dependent bird, mammal and fish species that rely on invertebrates as a food source. 3

A Chapter of the National Audubon Society

O-MAS

As the DEIR describes, seasonal wetlands are wetlands, but all of the discussions are focused on vernal pools, which is a type of seasonal wetland. Seasonal wetlands that are not vernal pools provide habitat for overwintering and migrating shorebirds and waterfowl. They are also frequently treated for mosquitoes. Please address the impacts of disturbance, physical modification and loss of insect populations resulting from chemical and other treatments, on seasonal wetlands that are not vernal pools and on the insect, bird and other wildlife that feed, rest and nest in seasonal wetlands. 4

The DEIR acknowledges that the treatment for mosquitoes "could affect the food web" either through toxicity or impacts on non-target organisms. (page 4-51). We consider this to be a potentially significant impact. There needs to be a more comprehensive discussion and information provided about food web impacts We have a number of questions:

- Insect loss is discussed in terms of loss of mosquitoes as a food source, or for other insects, such as dragonflies, stating that the populations of these other species will rapidly be replaced by populations from nearby. How is nearby defined? How close would they have to be? What studies are there that demonstrate that this occurs? Why wouldn't it be assumed that mosquitoes too would be rapidly replaced? 5

- The DEIR acknowledges that "Pesticides can kill natural predators of mosquitoes." Pesticides also kill other non-target species that are part of the food web. Provide a detailed explanation that identifies and discusses the insect species that are part of the food web of the Marin and Sonoma aquatic environments. What insect species occupy our tidal and seasonal marshes that would be expected to be present during the times periods the District treats for mosquitoes in those wetlands? Which of these species would be adversely affected/killed by chemical treatments for mosquitoes? What species occupy our marshes that would not be expected to be impacted by the pesticides used by the District? What species would be expected to survive chemical treatment for mosquitoes and remain in a wetland habitat after treatment so that they can support higher order species? Is it possible/probable that the pesticides used would eliminate all of the insects in a given wetland? 6

- Explain the statement (p-4-73) "In general, when a compound or its breakdown products decomposes rapidly in the environment and does not persist for extended periods, then the compound or product poses a lower risk to non-target species and a lower potential for environmental pollution." To understand the lower risk, it is necessary to have "rapidly" and "extended periods" defined. 7

- The DEIR states that the impact of treating seasonal wetlands is not significant because only small areas area treated. Discuss what is meant by "small area" so that this claim is verified. It is our experience in north Marin County that most if not all of the wetlands are treated and these do not add up to small areas. 8

- According to the DEIR (page 4-74), the utilization of resources by wildlife shifts by time of day and season. "If the availability of one resource decreases, the consumer can generally replace that with another resource." Please provide information to support 9

O-MAS

these statements. Certainly migratory species are seasonal i.e. present during fall, winter and spring. Aside from this, a significant reason aquatic species move around is because they must feed when the tides are in or our, or when water levels are high or low for others. We do not see why higher food web species such as ducks and shorebirds, would not use them all at the same time. Why would birds be expected to eat only one species of insect until that resources is eliminated, and only then move on to another? The assumption that another resource would be available to be used by wildlife, if one or more are eliminated, also is not substantiated. If all or most of the insects in a given wetland or area of wetland are eliminated, then this could result in a significant impact on the migratory and special status species. 9

The discussions of impacts on aquatic resources are full of vague qualifiers that inhibit understanding of the true nature of the impacts of pesticides that are used. Some examples are: "In general the pesticides used for mosquito control exhibit low or no toxicity to birds or mammals" and pesticides are "generally" used at levels that are "below the effects threshold" for other insects. Under what circumstances would the effects be higher? Identify the other insects that would be impacted. Under what circumstances would the pesticides be toxic to birds and mammals? 10

The loss of mosquitoes as part of the food web must be considered together with the loss of other insect species that are also part of the food web. How is small defined? Taking the North Marin area, much of the land MAS owns along with the publically owned land is treated. This is not a small area. 11

The last time the District did an EIR on the District's program, and we brought up our concern about the tracks left by off-road activities with ATVs/argos leave tracks in the marshes. These depressions are unsightly, damaging to beneficial vegetation and are breeding grounds for mosquitoes. This must be recognized as an adverse impact and discussed. 12

Several corrections to Table 4-4 are needed: 13

Page 4-36 California Black Rail Point are not primarily found in fresh water marshes. Their preferred habitat is brackish to salt marsh such as associated with Black John Slough in Marin County.

Page 4-37 California clapper rail – the name should be changed to Ridgway's rail and the habitat description revised to show that the primary habitat for this species is cordgrass channels in tidal marshes, not pickleweed.

.

Thank you for considering and responding to our comments and questions.

Sincerely,

Barbara Salzman, Co-chair
Conservation Committee

Phil Peterson, Co-chair
Conservation Committee

Comment Letter O-MAS

Marin Audubon Society

Barbara Salzman, Co-chair
Phil Peterson, Co-chair
September 29, 2015

Response 1

Comment noted and considered. No response is required.

Response 2

The District communicates with MAS several times annually regarding the District's operations on MAS properties and has done so for many years. We have assisted MAS in disseminating information regarding unauthorized trespass on their properties by the public and with their restoration projects. For, example, we have met with MAS staff and contractors regarding avoidance measures for restorative wetland plantings; participated in MAS restoration project meetings, planning, and monitoring; and assisted with the implementation of MAS restoration projects.

There are BMPs that specifically mention the resource agencies, specific wildlife refuges, and the public. The PEIR text mentions coordination with landowners in particular where sensitive habitats may be the subject of vector control. Most of the coordination with private landowners occurs initially during surveillance and then again if either chemical or nonchemical treatment is needed. In particular, it is the large-area landowners such as the Marin Audubon Society with whom coordination with the District beyond the usual public requests for service is most likely to occur. The request for a BMP that commits the District to coordination with nonagency/government property owners can be met with the following modification to BMP A1:

> District staff has had long standing and continues to have cooperative, collaborative relationships with federal, state, and local agencies and with special interest groups and land managers/owners. The District regularly communicates with agencies, organizations, and land managers/owners regarding the District's operations and/or the necessity and opportunity for increased access for surveillance, source reduction, habitat enhancement, and the presence of special status species and wildlife. The District often participates in and contributes to interagency and special interest group projects. The District will continue to foster these relationships, communication, and collaboration.

Response 3

The comment is concerned with impacts to migratory waterfowl and shorebirds and the loss of invertebrates on marsh dependent bird, mammal, and fish species that rely on invertebrates as a food source. The underlying question is a concern that removing mosquitoes as a food source would impact substantially other invertebrate and vertebrate species. There are two aspects to this comment addressed below: (1) the removal of mosquitoes and possible indirect effects on other invertebrates and then (2) the potential for the removal of the mosquito food source to impact other species.

The District's objective is to reduce or minimize the possibility of unwanted nontarget effects in the local environment while addressing the need for vector control that guides all nonchemical control as well as pesticide applications. These considerations and how unwanted effects can be eliminated or reduced are embodied in the Program objectives and in each of the applicable BMPs. By restricting chemical applications to times when nontarget insects are not active and using care to treat only vector larvae and adults in locations where they are concentrated (i.e., population is high enough to warrant control), impacts to other species are eliminated or substantially reduced to a level of less than significant. Control of problem insect populations is a public health concern; and the District's treatment using specific

pesticides is based on selection of the most effective, yet environmentally compatible, chemical option. If specific insect populations were to be reduced substantially at a given site or within a portion of a given site, there is minimal impact on the insectivorous birds, as they have large foraging ranges and are not dependent on a particularly localized population. This is especially relevant to the migrating bird populations that travel miles in their foraging events.

The District uses pesticides that are highly specific to mosquitoes. For example, two of the mosquito larvicides the District uses (e.g., *Bacillus thuringiensis* and *Bacillus sphaericus*) have been shown to be very specific to mosquito larvae, and nontarget impacts are minimal to nonexistent for invertebrates or amphibians (Glare and O'Callaghan1998). Lawler and Dritz (2013) report that the larvicide spinosad is an effective treatment for mosquito larvae at recommended doses but that at doses greater than those that kill mosquito larvae it can kill mayflies and some other nontarget insects that may serve as prey items for other species. Therefore, Lawler and Dritz (2013) indicate that doses that are effective against mosquito larvae are below levels that would even marginally impact nontarget insect populations. If an impact occurs it would be inconsequential. Even if the spinosad application for mosquito control impacts some individuals in a nontarget insect population, these nontarget populations are reproductively robust and the time to replace the individuals in the population is relatively short (Emlen 1989).

Most mosquito predators have evolved to use several sources of prey available to them at most times. Removal of mosquito larvae through vector control activities is unlikely to affect CTS larval food sources, for example, since the mosquito larvae and pupae do not constitute an important part of their diet, nor the diet of their primary prey. CTS larvae consume a variety of food items including aquatic invertebrates, primarily small crustaceans, as well as Pacific chorus frog tadpoles and snails (Anderson 1968). After hatching, larvae feed primarily on small invertebrates, switching to larger prey (tadpoles and snails) within about two weeks to support their rapid growth. Mosquito larvae and pupae were not found in the stomach contents of CTS larvae in this study, which was conducted in Santa Cruz County, California.

The Draft PEIR disclosed a broad range of issues associated with chemical methods of vector control and made a reasonable effort to address those issues in a manner understandable to the public by PEIR preparers with the appropriate qualifications. The issue of loss of prey and prey habitat is considered by a senior toxicologist in the extensive response below to support the material in Section 4.2.2.6 of the Draft PEIR and the following statement in the Draft PEIR on page 4-75 on predator populations, which is modified as indicated for greater clarity:

> "Mosquitoes are part of the food web and their loss may reduce the food base for some predators. Although mosquitoes serve a role as one of many types of prey items for some fish, avian insectivores, bats, and small reptiles and amphibians, the reduction of mosquito abundance over a small area will not affect the predator populations overall <u>because these species generally have large foraging ranges and can find</u>~~, as~~ other prey sources <u>within the range of their habitat use</u>~~ are available~~." <u>(Williams et al, 1994)</u>

Because of the selective nature of the vector control products for mosquitoes, any potential adverse impact to insect predator populations associated with District applications (as nontarget exposures) would be temporary and inconsequential in the impact to those populations' predator species. Even in the event of ancillary exposures, the recovery of such populations occurs rapidly to maintain the general level of individuals in their populations. The relative higher sensitivity of the target vs nontarget (less sensitive predator) species provides an adequate measure of safety to maintain the balance of predator populations.

Response 4

The commenter requests additional information specifically on potential impacts to seasonal wetlands (not vernal pools) that provide habitat for overwintering and migrating shorebirds and water fowl from vector control disturbance, physical modification, and loss of insect populations.

Control of mosquito populations is a public health concern, and the District's response using specific pesticides is based on selection of the most effective, least harmful, chemical option. Where insect populations are reduced substantially, there is minimal impact on the insectivorous birds since they have large foraging ranges and are not dependent on a particularly localized population. This is especially relevant to the migrating bird populations that travel miles in their foraging events. While management options include control by removing some or most of the unwanted vegetation in these areas, this alternative can result in a greater impact on the habitat used by the migrating shorebirds and waterfowl.

Proper and prudent use of pesticides for vector control thus can substantially lower the potential for an environmental impact on avian species compared to other alternatives. The primary loss of insect populations is the loss of mosquitoes (larvae, pupae, and adults), which does not substantially impact other nontarget insect populations and wildlife as explained in Response 3 above.

Disturbance to both species and habitats is discussed in the PEIR initially under the Surveillance Alternative and then subsequently under the Physical Control and Vegetation Management Alternatives for special-status species and 15 habitat types in both Chapter 4, Biology-Aquatic and Chapter 5, Biology-Terrestrial. The PEIR's consideration of impacts to seasonal wetlands and the species that occupy these wetlands is not limited to vernal pools, but it does include specific reference to vernal pools because they are an area of particular concern to the resource agencies. For example, under the Physical Control Alternative (Section 5.2.4.1.11), the following text is provided:

> "Because of the sensitive nature of seasonal wetland habitat types, the District generally would not undertake physical control measures in these areas. In the event that physical control in seasonal wetlands or vernal pools was required, the District would not implement water management and vegetation removal actions without previously discussing them with the relevant regulatory agencies or refuge wildlife managers to verify that no other alternative or option is preferable to control the mosquito problem at that location and to make sure that any such activity would be done in such a way as to minimize its impacts. As a result, this "consultation prior to implementation" BMP and the practices described above would result in a less-than-significant impact to terrestrial resources." (page 5-45)

In situations where there is potential for physical control/source reduction within a seasonal wetland habitat, the District will typically utilize chemical control for mosquito populations; while physical control strategies are explored and/or planned to minimize impacts to avian species.

An example of wetland habitat used by bird watchers and regularly monitored and treated with mosquito larvicides and adulticides annually (mosquito populations have tested positive for West Nile virus) is the Ellis Creek Water Recycling Facility along the Petaluma River in Petaluma, CA. Typical species observed at this spot are: Great Egret, Snowy Egret, American Coot, Northern Shoveler, Gadwall, Green-winged Teal, Cinnamon Teal, American Wigeon, Mallard, Greater Scaup, Sora, Virginia Rail, Greater Yellowlegs, Lesser Yellowlegs, Wilson's Snipe, Killdeer, Willet, Long-billed Curlew, Long-billed Dowitcher, Western Sandpiper, Least Sandpiper, Canada Goose, Mute Swan, Turkey Vulture, Red-tailed Hawk, Red-shouldered Hawk, Northern Harrier, American Kestrel, White-tailed Kite, Cooper's Hawk, American Crow, Black Phoebe, Say's Phoebe, Western Scrub-jay, Raven, Northern Mockingbird, Western Meadowlark, Red-winged Blackbird, Brewer's Blackbird, Marsh Wren, Tree Swallow, Bushtit, American Robin, Yellow-rumped Warbler, House Finch, European Starling, American Pipit, Song Sparrow, Savannah Sparrow, Golden-crowned Sparrow, White-crowned Sparrow, American Goldfinch (Talcroft 2015) (http://www.colintalcroft.com/Sonoma_County_Bird_Watching_Spots/Ellis_Creek_Water_Recycling_Facility,_Petaluma.html). Many hundreds of bird species have been observed in the expansive wetlands of southeast Petaluma. Recently in January-March 2016, a group of white-faced ibis (migratory species) was observed in the habitat around Petaluma's Ellis Creek water treatment plant and may be overwintering there (Gneckow 2016). The Ellis Creek Water Recycling Facility wetland is an example of seasonal wetlands where the District conducts active surveillance and chemical treatment, using both

larvicides and adulticides, and these methods have not interfered with the success of the area as seasonal wetland avian habitat. Furthermore, since birds are susceptible to West Nile virus, mosquito control is important to the health of avian species.

Response 5

The Draft PEIR identifies the potential for food web impacts as an environmental issue but the principal question is whether there are any significant impacts to nontarget species, which is the fundamental question in dealing with food webs. If nontarget species are not substantially impacted by the loss of mosquitoes as a food source, then neither are the related food webs through indirect effects on the other species. If there were an impact determined to be significant, then the species affected would need further analysis. An entire chapter in the PEIR has been devoted to potential ecological health impacts associated with nontarget species (see Chapter 6, Ecological Health) which is based on Appendix B, Ecological and Human Health Assessment Report. The responses herein are prepared by the principal toxicologist on the PEIR, Bill Williams, PhD. Dr. Williams was a charter member of the Avian Dialogue Group, convened by the Conservation Foundation (RESOLVE) to bring industry, academia, and government regulators together to resolve conflicts between the groups on matters dealing with pesticides in the environment and led the preparation of the PEIR Appendix B, Ecological and Human Health Assessment Report.

Concerning the comment on rapid replacement and the choice of words such as “nearby” in the PEIR, which is written as a CEQA document where scientific studies and complex material contained in Appendix B is summarized and written to be understandable to nontechnical readers, the following information is provided. The replacement of insect populations after a significant stress to their numbers can occur within weeks to months. In most higher trophic level species, a reduction in numbers by as high as 30 percent or more is still below the level for irreversible population impacts or extinction. In a study focused on invertebrates and higher tropic level birds and offspring after exposure to a common mosquito larvicide (Golden Bear Oil, GB-1111), Miles et al demonstrated that ducklings held intermittently on the ponds over an 8-day period showed cold related hypothermia but no significant effects of weight loss due to invertebrate prey depletion. (Miles et al. 2002). Insect population replacement based on proximity is only an issue where a highly localized population of a specific insect is being exterminated, and that is not occurring with mosquito control for the reasons cited in Response 4 above and Response 6 below. Nontarget insect predators are not being removed in substantial numbers.

Concerning the question about rapid replacement of mosquitoes, the District’s surveillance, physical control, vegetation management, and chemical control components (alternatives) of the overall Program are designed to inhibit rapid replacement of mosquitoes.

Response 6

Concerning the many questions on other insect predators, the response herein is provided. It is important to note that the majority of chemical mosquito control operations utilize larvicides to control mosquito larvae. The mosquito larvicides used by the District, as labeled for mosquito control, have minimal if any nontarget impacts. Adult mosquito control products (i.e. adulticides) are used less frequently. The detailed analyses of the materials used in chemical control portion of the District’s IVMP (including scientific references) are included in Chapter 6 and Appendix B of the PEIR.

The use of vector control products is based on selection of specific chemical products that have been tested for efficacy and specificity by the USEPA and other regulatory agencies. Information about the toxicity of each chemical that may be used in the Program is contained in Appendix B. The information in Appendix B has been considered by the PEIR preparers in evaluating the potential Program effects on insect populations and the food web in general. The potential impact to nontarget insects is considered and the relative impact to these species is weighed against the CEQA criteria and questions for this PEIR.

The PEIR contains extensive evidence and analysis supporting a determination that Program impacts to nontarget species, and thus the larger food web, will not be significant. The suggestion that the PEIR evaluate the specific toxicity of each potential chemical on each potential insect found in the County is beyond the scope of a PEIR as it would require a monograph based on substantial original graduate level scholarly research.

In considering the PEIR and whether to continue the Program as it is being implemented or adopt one of the CEQA alternative Programs (e.g., Reduced Chemical Alternative Program), the District decision makers (Board of Trustees) will consider the PEIR evidence in light of the importance of control of the unwanted species and the District's mission to protect public health. Current problems with insect vectors that may be carriers of disease (i.e., consider the potential impact of malaria, dengue, leishmaniasis, Lyme, and even Zika), as conveyed by both flying and crawling insects require intervention/control. The District must determine the appropriate balance between protection of public health and the possible temporary reduction in a localized insect population that does not threaten the survival of other species. No insecticide treatment has or can completely extinguish one of these insect predator populations. Eradication of any insect is extremely difficult to accomplish and is not the objective of the District's Program.

Response 7

The cited statement is found in Draft PEIR Section 4.2.2.5, which is part of the explanation of assumptions and/or background material related to the analysis of hazards, toxicity, and exposure for chemical treatment methods. The discussion is meant to inform the general public about scientific principles and practices, and is not detailed in its use of terms that apply to a range of data presented in Appendix B, especially in Table 6-1. This is an interpretation of the data on how long the active ingredient is "active" or effective once it is subject to environmental factors at the application site. Understanding the risk of impact to nontarget species and an active ingredient's persistence in the environment is related to understanding the following physiochemical factors:

It has been demonstrated and validated over decades that every organic chemical has a physical/chemical degradation characteristic termed "half-life" (a metric used to describe the elapsed time for a chemical to reach ½ of its initial activity). Each organic chemical, whether toxic or not, decays in both activity and toxicity over time. For some chemicals, the half-life can be hours, days, or weeks. By design, few chemicals used as pesticides have half-lives greater than a week and are further degraded by the environmental conditions of the application area. When pesticides get into soil, or water, or are taken up by plants and animals, the half-life characteristics are altered. The environmental fate of pesticides depends on the physical and chemical properties of the pesticide, particularly the pH of the medium, modifying how likely it is to travel through soil (soil mobility), how well it dissolves in water (water solubility), and how likely it is to become airborne (volatility). Once a pesticide has been released into the environment, it can be broken down by exposure to sunlight, (photolysis), exposure to water (hydrolysis), exposure to other chemicals (oxidation and reduction), microbial activity (bacteria, fungi, and other microorganisms), and other plants or animals (metabolism). Most of the new generation chemicals (nonorgan chlorines) break down in soils in a few hours to days, depending on the soil characteristics. Pesticides that are considered to persist for extended periods are generally those that break down rapidly when applied but continue to break down at a slower rate after the initial decrease in measurable concentration. Some pesticides can be found in trace amounts after extended times, but the trace levels are too low to be of consequence. Pesticide labels set out safety and use guidelines that usually focus on three aspects: rates of application (single and cumulative) for registered crops and pests, timing of application, and restrictions on areas of application (including required buffer zones).

The environmental fate of the pesticides used by the District is influenced by their chemical properties and by the environmental conditions in which they are applied. The PEIR's Appendix B, Ecological and Human Health Assessment Report, provides a detailed description of the fate and transport in air, water, and soil for each of the active ingredients applied by the District (and eight other districts). A summary of

the potential uses of pesticide products by the District is included in Appendix B Table 6-1 and the narrative addressing each of the active ingredients of interest. As noted, many second-and third-generation insecticides are formulated to act quickly and then dissipate quickly in the environment, often through photolysis or microbial breakdown. Others bind to soils and sediments where they are degraded abiotically or by soil organisms. These effects, the potential for mobilization after pesticide application and the methods used to minimize exposures to unwanted receptors, are considered in the discussion of the Vegetation Management and Chemical Control Alternatives (see Sections 9.2.5 and 9.2.7 of the PEIR).

Response 8

The commenter appears to have taken the statement out of context and has not provided a page number. The preceding comment 7 and the subsequent comment 9 are on pages 4-73 and 4-74. Each impact statement is preceded by an explanation of the reasons why the impact is less than significant. In the case of the Physical Control Alternative, the conclusions that the Program would have less-than-significant impacts on special-status species and habitats is based on extensive evidence and analysis by habitat type. Section 4.2.4.1.4 Seasonal Wetlands (Including Vernal Pools), contains the following information to support the conclusion (in part):

> "The availability of such habitats has been substantially reduced by human land use practices and flood control measures. Reducing the frequency or duration with which such habitats are flooded would adversely affect habitat and aquatic resources. The Physical Control Alternative would not reduce the quantity of this habitat, but simply improve circulation within the marsh. Only inactive channels would be filled to eliminate ponding. All work in wetlands would be subject to additional permitting by the USACE, CDFW, BCDC, and RWQCB." (page 4-81)

As part of its ongoing (at least once annually and typically several times annually) discussion with MAS staff of mosquito surveillance and control on MAS lands with MAS staff, District staff notifies MAS when large-scale aerial mosquito larvicide treatments are conducted on their properties (e.g. 50-160 acres need to be treated with mosquito larvicide). Chemical larvicide treatments of this size are usually done by helicopter and minimize physical disturbance to avian and animal species from people and equipment. Other wetlands of this size in the Highway 37 corridor may require aerial larviciding. Mosquito production within wetlands ranging from 1 acre up to 50 acres in size are typically treated on foot using backpack application equipment and equipment mounted on/from ATVs and the airboat. The District will aerially apply a mosquito larvicide(s) in a wetland smaller than 50 acres if there are already aerial applications scheduled and efficiency can be achieved, if the mosquito population(s) are in the later stages of the lifecycle and timing of ground based application is an issue, if there are site access issues, or dense and abundant vegetation is present that results in larvicide penetration issues. These methods are also used within larger wetlands in which only small sections have mosquito production, i.e., a 100-acre wetland that has 15 acres in mosquito production. It is common to find mosquito production in portions of seasonal and tidal wetlands and not throughout the entire site. Localized treatment of mosquito production according to the District's BMPs ensures that impacts to wetland habitat are not substantial.

Response 9

As a result of the highly selective nature of the District's mosquito and vector control activities (and chemicals), the Program will never result in elimination of all insects from a particular habitat. In any event, the temporary elimination of one type of insect at a particular location would not have an adverse effect on predator species. All wildlife species of birds and mammals forage for food over distances appropriate to their species and habitat availability. The foraging range of birds and mammals are well documented in numerous US Fish and Wildlife journals and USEPA Wildlife Exposures Handbooks (1 and 2) which include the potential foraging ranges for terrestrial mammals and birds. The consumption of selected prey items by these species generally occurs over extended distances (miles or more), and they

are thus able to obtain food items in areas beyond application areas. It has been demonstrated, in fact, that most birds and mammals will avoid contaminated food items when alternative choices are available. The comment suggests a misunderstanding of the descriptions of food web foraging strategies as the species of interest do not consume a prey species until extinct, rather the food preferences for most species are varied and not limited to one species of prey. Food webs are described by several trophic level discriminators, including those that consume lower prey species, vegetation choices, and predator/prey hierarchy. The range of foraging areas and site fidelity range from the extremes of migratory birds which have foraging ranges of hundreds to thousands of miles, to many shore birds with ranges of dozens of miles and the ability to utilize numerous prey items in their foraging events.

Response 10

The commenter objects to the statements that summarize toxicity data for the general reader of a PEIR and is interested in the exceptions and how the broader statements are supported. Consistent with the CEQA Guidelines and CEQA best practices, the District has included highly technical information in an appendix and summarized that information in language understandable to the general public. The commenter is directed to Chapter 6 Ecological Health for its coverage of the chemicals used or proposed for use by the District, because relevant information related to toxicity presented in Chapter 4 Biology-Aquatic and Chapter 5 Biology-Terrestrial was summarized from the information in Chapter 6. Chapter 6 information on toxicity, fate, and transport of the chemicals and effects on various vertebrates and invertebrates is summarized from the data contained in Appendix B, Ecological and Human Health Assessment Report, especially the tables contained in the text.

The PEIR includes numerous examples of the Program pesticides in use today (or proposed for use in the future) and comprehensive tables of species sensitivity to each. Each pesticide is evaluated in USEPA in-house or contract laboratories to determine the thresholds for acute and chronic toxicity. These tests, in confined laboratory conditions, expose numerous species of concern to 100 percent chemical in food or direct injections of suspended chemicals. In these evaluations the test animals are not provided any alternative food choices that are typically available in the field under natural conditions. As a result of this testing technique, the results of the laboratory tests are far more extreme and certainly can be considered “worst case” exposures and not particularly realistic. However, the purpose is to determine the levels of sensitivity to the test chemical and to develop recommended application rates that provide a large margin of likely safety to the exposures that might occur in the field. Because the District uses chemicals only at recommended application rates for the vector species involved, Program chemical use would not be expected to exceed, or even approach, toxicity thresholds for nontarget species. A table of some of the hundreds of test results can be found in Appendix B, Table 6-1, as summarized in selected entries as examples from that table listed below.

Response 11

See Responses 3 through 10 above.

Table 6-1 Toxicity Values Reported in the Literature for Active Ingredients

Active Ingredient	Mammalian Oral LD50 (mg/kg)[A]	Mammalian Dermal LD50 (mg/kg)[B]	Mammalian Inhalation LC50 (mg/L)[A]	USEPA Tox Rating	Avian LD50 (mg/kg)[C]	Fish LC50 (mg/L)[D]	Aquatic Invert EC50 (µg/L)[E]	Honeybee LD50 (µg/bee)	Other Receptors
Pyrethrins	1400	>2,000	3400	oral and dermal (III), inhalation (IV)	>5,620	0.0051	11.6	no data, likely toxic	no data
Allethrins and *d-trans* allethrin	685 (allethrin, F) 860 (d-trans)	11,332 (allethrin)	no data	no data	>2,000 (allethrin) >5,620 (d-trans)	0.0026 to 0.08	no data	3 to 9	Dog dietary NOEL = 50 mg/kg/Day for 2 years.
Phenothrin (sumithrin or d-phenothrin)	>5,000 (no deaths)	>2,000 (no deaths)	>2.1 (no deaths)	oral and inhalation (IV), dermal (III)	>5,000	0.0158	4.4	no data, likely toxic	no data
Prallethrin	460	>5,000	0.66	no data	1,171	0.012	6.2	0.028	no data
Deltamethrin	>5,000	>2,000	no data	no data	no data	no data	no data	no data	no data
Esfenvalerate	458	2,000	2.93		9,932	0.00026	0.00024	highly toxic	no data
Lambda-cyhalothrin	56 to 144	632 to 696 (rats)	no data	no data	>3,950	0.0021	0.36	0.97	no data
Resmethrin	4,639	>2,000	5.28	no data	75 (blackbird)	.00028	0.063	0.963	no data
Tetramethrin	>5,000	>2,000	no data	oral (III), dermal (IV)	>2,250	0.0037	45	0.155	no data
Permethrin	2280	>2,000	no data	oral and dermal (III), inhalation (IV)	>10,000	0.00079	0.1 (mayfly)	0.13	toxic to cats via dermal route
Etofenprox	>2,000	>2,100	>5.9	no data	>2,000	0.0027	no data	0.27 (oral), 0.13 (contact)	Dog oral LD50 >5,000 mg/kg
Piperonyl butoxide (PBO)	4,570	>2,000	>5.9	oral and dermal (III), inhalation (IV)	>2,250	1.9	510	>25	Tadpole LC50 = 0.21 mg/L
Naled	81 to 85	354	0.19	all acute (II)	52	.087 (lake trout), 2.2 (bluegill)	0.3	0.48	no data
Temephos	444	970	1.3	oral and dermal (II), inhalation (III)	no data	3.49	10	no data	no data
Bacillus sphaericus (Bs)	no data	no data	no data	no data	no data	>15.5	15,500	no data	no data
Bacillus thuringiensis (Bti)	>4,7x10^{11} spores/kg	>2.67x10^{11} spores/kg	4,7x10^{11} spores/kg	all acute (IV)	no data	no data	50,000 (10 Days)	no data	no data
Spinosad	>5,000	>2,800	>5.18	no data	>2,000	5.9	92,700	11,500	Butterfly/moth LD50 = 0.022 mg/kg. No effect on amphibians.
Methoprene and s-Methoprene	>10,000	>2,000	>210	oral and inhalation (IV), dermal (III)	>2,000	>50	89	no data	Frog LC50 >10,000 µg/L
Alcohol Ethoxylated Surfactant (monomolecular film)	no data	no data	no data	no data	no data	No observable effects	No observable effects to shrimp, snails, worms, or mayfly naiads	no data	No observable effects to amphibians.
Aliphatic solvents (mineral oils, aliphatic hydrocarbons, petroleum distillates)	>28,000 (no deaths observed)	>5,000	3.9	no data	>2,250	no effect	<900	no effect	no data
Potassium Salts (soap salts)	no data	no data	no data	all acute effects (IV)	no data	no data	no data	no data	no data
Chlorophacinone	3.15 (rats)	0.329	.007	all acute effects (II)	258	0.45	640	no data	Carnivorous mammals LD50 = 2.1 to 50 mg/kg

Response 12

The comment is concerned with existing off-road tracks caused by off-road vehicles. Such effects may be associated with the District's surveillance and subsequent control activities in the marshes but also from the others who manage the land, including the state and federal refuge managers. Existing tracks are part of the existing condition, and the PEIR impact analyses consider the Program's ATV use in light of the District BMPs designed to avoid creating new tracks by staying on existing tracks or using foot access and by implementing measures in the USFWS's "Walking in the Marsh: Methods to Increase Safety and Reduce Impacts to Wildlife/Plants" (see BMP B1). District BMPs B1 through B6 are for vector control activities in tidal marsh areas. In particular, BMP B2 states the following:

> "District will minimize the use of equipment (e.g., Argos) in tidal marshes and wetlands. When feasible and appropriate, surveillance and control work will be performed on-foot with handheld equipment. Aerial treatment (helicopter and fixed wing) treatments will be utilized when feasible and appropriate to minimize the disturbance of the marsh during pesticide applications. When ATVs (e.g., Argos) are utilized techniques will be employed that limit impacts to the marsh including: slow speeds; slow, several point turns; using existing levees or upland to travel through sites when possible; use existing pathways or limit the number of travel pathways used." (page 2-59)

District staff operate ATVs (e.g., Argos) with great care in seasonal wetlands and tidal marshes in general as well as in MAS-owned properties. Argos are typically used, in part, because of their low ground pressure. They are necessary because of the amount of acreage that requires surveillance and/or treatment or because of safety hazards that exist. For example, one of the seasonal wetlands in Bahia can develop large underwater cracks that can result in serious injuries if trying to walk in the wetland. The District minimizes ATV use as much as possible through mosquito source reduction and physical management. Furthermore, the District assists MAS in managing seasonal wetlands by managing water control structures to maximize habitat while minimizing mosquito production, the need for larvicide applications, and ATV use. Argo tracks are also temporary, often flatten (but generally do not kill or remove) vegetation, and typically do not create "depressions". The aesthetic effect of such temporary vegetation disturbance is subjective; in the District's judgment such limited and temporary disturbance does not constitute a substantial adverse change in the visual character of the properties it treats. Visible Argo tracks do not create "breeding grounds" for mosquitoes.

Response 13

The corrections to Table 4-4 on pages 4-36 and 4-37 will be addressed in the text changes (Section 6.2) of this Final PEIR.

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O-MCGP

Marin Greens
marin county green party

October 2, 2015

Philip D. Smith, District Manager,

Marin Sonoma Mosquito Vector Control District

595 Helman Lane, CA 94931

Dear District Manager Smith:

The Marin County Green Party, through its County Council, thanks you for the opportunity to comment on the use of glyphosate by the District. Marin County's Green Party strongly supports and urges you to adopt a ban on glyphosate-containing herbicides.

Recently, the World Health Organization (WHO) found glyphosate, the active ingredient in Monsanto's Round Up, a probable carcinogen and a significant body of emerging research tends to demonstrate a wide range of serious concerns raised by its continued use in our environment.

These concerns include -

- the proliferation of glyphosate-resistant weeds;
- the impacts of glyphosate on bees, especially with respect to its effects on the plants they depend on and their ability to navigate back to the hive;
- the overall impacts on non-target plants, animals, insects and micro-organisms which may be exposed to glyphosate-containing herbicides;
- glyphosate contamination in soil and the balance of bacteria and fungi, soil ecosystem functions and plant health;
- impacts on the growth and development of amphibians;
- surface and groundwater contamination with highly soluble glyphosate; and
- the persistence of glyphosate in the environment due to a lack of biodegradation.

1

There appears to be a trend demonstrating a scientific consensus coalescing around the conclusion that glyphosate may pose serious dangers in a variety of ways. (See, for

2

O-MCGP

example, comments from Sustainable TamAlmonte and others on the Draft Marin County Open Space District (MCOSD) Vegetation and Biodiversity Management Plan and the Draft MCOSD Vegetation and Biodiversity Management Plan Tiered Program Environmental Impact Report: http://www.tamalmonte.org/letters/Sustainable_TamAlmonte_et_al_Comment_Letter_on_DRAFT_TPEIR_of_DRAFT_MCOSD_VBMP_7-6-15.pdf); New effects of Roundup on amphibians: Predators reduce herbicide mortality; herbicides induce antipredator morphology, Rick Relyea, Ecological Applications, 22(2), 2012, pp. 634–647; Effects of sub-lethal doses of glyphosate on honeybee navigation, María Sol Balbuena, Léa Tison, Marie-Luise Hahn, Uwe Greggers,Randolf Menzel, and Walter M. Farina. 2

The recent WHO finding that glyphosate is "probably carcinogenic to humans" was based on an International Agency for Research on Cancer assessment. Many of those who oppose the findings are associated with the biotech industry. 3

Rather than rely on the use of glyphosate to reduce fire threats, we believe that we can more effectively reduce fire danger by stepping up maintenance of existing fire breaks and judiciously expanding the use of controlled burns, mowing, manual removal, grazing, chipping and composting of unwanted vegetation and underbrush. We also believe that glyphosate-based herbicides may actually increase the fire threat by their desiccant effect on non-target vegetation including sensitive native species. 4

The Marin Green Party espouses ten Green Party values and the first of these is "Ecological wisdom." We believe that human societies must operate with the understanding that we are part of nature, not separate from nature. We must maintain an ecological balance and live within the ecological and resource limits of our communities and our planet. We support a sustainable society which utilizes resources in such a way that future generations will benefit and not suffer from the practices of current generations. To this end we must practice regenerative land management practices which replenish the soil's ability to absorb more atmospheric carbon, reduce carbon emissions in our generation of power and live in ways that respect the integrity of natural systems. 5

We realize that the use of glyphosates is a controversial decision that you will not take lightly. If, after you review the scientific research available, you are still in any doubt, we urge you to embrace the precautionary principle by banning the use of the "probable carcinogen" glyphosate by the District. In doing so, you will be preserving the 6

O-MCGP

North Bay's beautiful, natural system, both for ourselves and for future generations. 6

Thank you for your consideration,

Mimi Newton,

Co-Chair, Marin Green Party on behalf of the

Marin Green Party County Council

Comment Letter O-MCGP — Marin County Green Party

Mimi Newton, Co-chair
October 2, 2015

Response 1

The comments express concern with the potential use of glyphosate by the District under the Vegetation Management Alternative for several reasons addressed below. The first concern of the MCGP is the World Health Organization (WHO) finding that glyphosate is a "probable carcinogen" and also a wide range of concerns demonstrated in emerging research (addressed after the WHO finding).

The **WHO report** is the result of a "panel discussion" (IARC) about the potential for selected chemicals and products that have achieved some level of public interest and concern but may or may not be supported by the data and information available. The panel is comprised of several European scientists and government organizations reporting to the WHO (a scientifically conservative advocacy agency) sponsored by the UN. In most of their reported reviews, the UN IARC has advocated the "precautionary principle" (WHO 2015). The "precautionary principle" is used by some members of the public to argue against chemical use. The precautionary principle is a hypothesis generally rejected by the scientific community that unless one can prove there is or can be no adverse impacts of a substance the substance should be considered hazardous. To those with scientific training, this suggests that one must "prove a negative" which is essentially impossible in any statistical sense in science. In short, the precautionary principle requires "proof of a negative" which demands that the studies disprove any possible unseen negative effect in order to accept the results of a study.

The IARC finding has been challenged by dozens of technical experts who evaluated the process used by the panel to list glyphosate as a probable carcinogen. It has been demonstrated that IARC rejected the 800 studies / 3,000 documents that gave glyphosate a positive safety result, basing their decision of "probably carcinogenic" on only eight studies, of which three actually included results that were themselves arguably insignificant. After the WHO publication listing glyphosate as a probable carcinogen, dozens of practicing scientists in the mainstream scientific community (including European Food Safety Administration, the German Federal Institute for Risk Assessment (*BfR*) and the lead author of one of the studies used by IARC to draw their conclusions) have criticized and disputed the results of the IARC for using a poor methodology and inadequate research. The conclusions drawn by the IARC about the potential adverse effects of glyphosate were based on studies that are not relevant to actual, potential exposures and on studies that were based on high exposures to petri dish cells and in vitro laboratory conditions.

Subsequent to the declaration on glyphosate, the IARC stated that bacon and other animal products are "possibly carcinogenic" but again, the declaration was challenged by several scientists who reiterated that there was no credible research that was clear enough to make such a claim (WHO 2015; Mink et al. 2012).

The District's use of glyphosate and other herbicides is for management of vector habitat and invasive weeds. When used, these herbicides are applied using targeted application equipment mounted from trucks/ARGOs or hand cans to avoid overspray onto other vegetation. The focus of herbicide use has also been on reducing or stopping invasive weed infestations and their spread associated with District activities in the wildlife refuges or in other sensitive habitats. We have provided assistance with and have partnered in invasive plant control investigations (e.g., pepperweed and *Ludwigia* ssp.) with other agencies. District staff are instructed to clean equipment after exposure to weed infested areas to limit seed dispersal.

On the issue of **glyphosate-resistant weeds**, the comment assumes that District use would contribute to the proliferation of this type of weed. Evidence for resistance to herbicides has long been observed in the agricultural use of some products, but this phenomenon is of little importance for District use at a smaller scale. The current and anticipated future use of glyphosate products by the District would not likely lead to

observable resistant vegetation in the District, as the applications are not at the levels used in agriculture. The development of resistance to herbicides by specific species of vegetation occurs over years of applications. However, to minimize the potential for the development of weed resistance in an application area, products containing glyphosate would be used in rotation with other products containing imazapyr or triclopyr if repeated applications were necessary at a given site.

On the concern about **glyphosate impacts on bees**, the District's objective is to reduce or minimize the possibility of unwanted nontarget ecological receptors or species effects in the local environment while addressing the need for vector control that guides all pesticide applications including glyphosate. These considerations and how unwanted effects can be eliminated or reduced are embodied in the Program objectives and in each of the applicable BMPs. By restricting chemical applications to times when nontarget insects are not active and using care to treat only vector larvae and adults when populations are large enough to warrant treatment, impacts to other species are eliminated or substantially reduced.

Furthermore, the vegetation management option of using glyphosate has been shown to be one of the least hazardous herbicide products for over 40 years. Glyphosate is practically nontoxic to bees. Claims that glyphosate impacts bees are based on a report by Herbert et al. (2014) that conducted simulated "field tests" to evaluate the effects of glyphosate on honeybee behaviors. These authors designed their study to determine what impact exposures to glyphosate might have on honeybee foraging and hive identification behaviors. Although the hypothesis of these authors predicted that honeybee behaviors would be adversely impacted after exposure to the herbicide glyphosate, the behaviors they studied were not adversely affected by the exposures and their conclusion was "no effect on foraging related behavior was found in these behavioral studies". In several studies, for instance, (Frasier and Jenkins 1972) indicate that both technical and formulated glyphosate are practically nontoxic to honeybees with a contact LD_{50} value greater than 100ug/bee (applied directly to the thorax with a saturated Q-tip), which is clearly considerably greater exposure than likely in the environment where applications could occur. Over the past decades, to update and support the original data submitted by Frasier and Jenkins, several studies on glyphosate have been conducted to confirm and validate the toxicity estimates first submitted to USEPA for registration. These studies have been submitted to the USEPA for inclusion in the Integrated Risk Information System (IRIS, USEPA). The recent data submissions and reports continue to support the finding that glyphosate is "relatively" nontoxic to honey bees (Porterfield 2015; Zhu et al. 2015; Giesy et al. 2000; see also Table 6-1 in Appendix B of the PEIR).

There are many credible theories as to the causes of the reduction in bee numbers (where they occur), including the effect of drought on the flora sources, the rise of parasites, fungi, and other classic bee diseases, and it is likely that these sources of stress are the most important adverse effects on bee colonies.

The concern about **impacts of glyphosate on nontarget plants, insects (other than bees), animals, and microorganisms** is addressed below. Products containing glyphosate (such as Alligare Glyphosate 5.4) are registered for use in habitat restoration and maintenance. The product label states: "When applied as directed, exotic and other undesirable vegetation may be controlled in habitat management areas. Applications may be made to allow recovery of native plant species, to open up water to attract waterfowl, and for similar broad-spectrum vegetation control requirements in habitat management areas. Spot treatments may be made to selectively remove unwanted plants for habitat enhancement. For spot treatments, care should be exercised to keep spray off of desirable plants." Adverse effects to desirable, nontarget plants can be readily avoided by applying the material according to District BMPs to minimize drift and spills (see PEIR BMPs H1 – 13 and I1 – 6, Table 2-9). Material presented in the PEIR's Appendix B, Ecological and Human Health Assessment Report (Section 4.6.2) and summarized in the discussion in the PEIR (Section 6.2.5.1.1, page 6-20) indicates that glyphosate is virtually nontoxic to mammals and practically nontoxic to birds, fish, and invertebrates (Appendix B, page 4-67). Glyphosate is an herbicide that is relatively stable to chemical and photo decomposition. The primary pathway of glyphosate degradation is soil microbial action, which yields the minimally toxic

breakdown product aminomethylphosphonic acid (AMPA) and glyoxylic acid. Both products are further degraded to carbon dioxide. Glyphosate adsorbs tightly to soil so that its residues are relatively immobile in soil (USEPA 1993). This characteristic results in the chemical (when it is in the soil) being less available as a route of exposure and would require direct ingestion of the soil or sediment, which is not likely by insect pollinators, who focus on flowers.

The commenter's concern about possible **contamination of soil and soil microorganisms** and function, is not supported by evidence. As stated above the primary pathway of glyphosate degradation is soil microbial action (under aerobic and anaerobic conditions), which would not occur if glyphosate were harming these microbes.

The commenter is concerned about glyphosate's **impacts on the growth and development of amphibians**. Some reports cited by the public suggest that the potential impact of glyphosate and glyphosate products includes adverse impacts to several life stages of amphibians and their habitats. These reports are not directly relevant to the potential impact of glyphosate on amphibians such as the California red-legged frog (CRLF) in the environment, as the data presented is based primarily on toxicity in laboratory studies using both high doses and several sequential lower doses in a laboratory setting. The toxicity of glyphosate to dozens of species is listed in Table 6-1 of Appendix B.

While the addition of some surfactants to glyphosate products may make the products more toxic to some biota, the primary concern for red-legged frog is toxicity based on studies using high, continuous exposures to the products in laboratory tests. The exposures in the laboratory studies are clearly not representative simulations of the potential exposures in field applications because the laboratory studies involve captive test species, unable to choose uncontaminated food or habitat. Many laboratory tests are designed and conducted to determine the "worst-case" exposure to a chemical and then to lower the test concentrations slowly until a test concentration shows no adverse effect to the test animals (USEPA 2012; Williams et al. 1994). In this way, the concentrations that produce exposures with little or no adverse response can be documented and used to define the applications that should be nonhazardous to the animals and environment. As in all of the relevant laboratory toxicity studies, the exposures in laboratory conditions are essentially 100 percent with no ability to choose areas of lessor concentrations, and use non-representative exposures. The best available evidence indicates that glyphosate toxicity would not occur as a result of the District's method of use of the chemical under the Program.

The primary causes identified by the California Department of Pesticide Regulation and California Department of Fish and Wildlife as leading to an adverse impact on the status of the threatened California red-legged frog are loss of habitat and overwhelming predation, invasive species, and competition for foraging items (National Wildlife Federation listings). The potential impact of glyphosate on the CRLF is marginal and only applicable in situations of excess exposure to incorrectly treated areas. The toxicity and adverse effects reported in laboratory studies would not be expected to occur as a result of the District's potential herbicide applications for mosquito habitat or invasive species control in the field, because of the much lower potential exposures and the District's adherence to its BMPs. Special care is taken to avoid applications where CRLF have been identified and reported by resource agency personnel or District biologists and technicians based on observations and database investigations.

The commenter is also concerned that **glyphosate could impact surface water and groundwater**. This issue is addressed in Section 9.2.5.2.1 of the PEIR, page 9-28:

> "Glyphosate is a nonselective, post-emergent, and systemic herbicide registered for use in agricultural and nonagricultural areas. It is used to control emergent foliage, but is not effective on submerged or mostly submerged foliage. Glyphosate is highly water-soluble, but binds tightly to soil and sediments. It has a low tendency to run off when applied to land because of strong adsorption to soil particles and it has a low potential to move to groundwater. Glyphosate degrades in soil in about a month. It has low toxicity to fish and aquatic invertebrates."

The conclusion was that application of the herbicide active ingredients imazapyr, glyphosate, triclopyr and the adjuvant alkylphenol ethoxylates (APEs) each would have a less-than-significant impact to surface water or groundwater resources when applied in accordance with label instructions and District BMPs.

The commenter believes that glyphosate is persistent in the environment due to a lack of biodegradation. This statement is not supported by the data, which indicates that glyphosate has a typical half-life of about 2 to about 40 days, depending on the environmental conditions. The average half-life of glyphosate *is* a moderately rapid rate compared with degradation of other compounds. The variability in rates of glyphosate degradation in the published literature is primarily due to the varying microbial activity and extent of soil-binding associated with the application area. This phenomenon is unrelated to the bioaccumulation potential. Uptake and bioaccumulation is related to specific chemical characteristics associated with the physical structure of each chemical.

For decades, scientists have demonstrated and validated that every organic chemical has a physical/chemical degradation characteristic termed “half-life” (a metric used to describe the elapsed time for a chemical to reach ½ of its initial activity). Each organic chemical, whether toxic or not, decays in both activity and toxicity over time. For some chemicals, the half-life can be hours, days, or weeks. By design, few chemicals used as pesticides have half-lives greater than a week and are further degraded by the environmental conditions of the application area. When pesticides get into soil, or water, or are taken up by plants and animals, the half-life characteristics are altered. The environmental fate of pesticides depends on the physical and chemical properties of the pesticide, particularly the pH of the medium, modifying how likely it is to travel through soil (soil mobility), how well it dissolves in water (water solubility), and how likely it is to become airborne (volatility).

Once a pesticide has been released into the environment, it can be broken down by exposure to sunlight, (photolysis), exposure to water (hydrolysis), exposure to other chemicals (oxidation and reduction), microbial activity (bacteria, fungi, and other microorganisms), and other plants or animals (metabolism). Pesticide labels set out safety and use guidelines that usually focus on three aspects: rates of application (single and cumulative) for registered crops and pests, timing of application, and restrictions on areas of application (including required buffer zones).

Also see information above on soil microbial action.

Response 2

The commenter is concerned with adverse effects of glyphosate identified by others on the Marin County Open Space District’s Vegetation and Biodiversity Management Plan, Draft Tiered Program Environmental Impact Report (MCOSD 2015). Specifically, the District is referred to a comment letter on the Draft PEIR; however, this letter was not provided and the hyperlink did not allow the PEIR preparers to access the TamAlmonte website. From an internet search, it appears the MCOSD has not published a Final PEIR, so this letter is not available publically. The comment also cites what appears to be two studies by Rick Relyea and by Maria Sol Balbuena et al. Neither study was provided by the MCGP, and no hyperlinks to these two studies were provided. The PEIR preparers are not obligated to conduct searches for research reports referenced in comment letters. Moreover, the referenced comments are comments on another EIR, not comments on the IVMP PEIR, and the commenter does not explain how the information in those comments, even if they were available, relates to the specific evidence and analysis in the PEIR.

The commenter did not provide the cited document on effects of sub-lethal doses of glyphosate on honeybee navigation. However, the PEIR preparers considered this issue and specifically a 2014 study prepared by Herbert et al that conducted simulated “field tests” to evaluate the effects of glyphosate on honeybee behaviors. These authors designed their study to determine what impact exposures to glyphosate might have on honeybee foraging and hive identification behaviors. Although the hypothesis of these authors predicted that honeybee behaviors would be adversely impacted after exposure to the

herbicide glyphosate, the behaviors they studied were not adversely affected by the exposures and their conclusion was "no effect on foraging related behavior was found in these behavioral studies". Disregarding their negative behavioral results, the authors suggested that the bees may have been able to carry pesticide to the hive (which was not and is not a measurable endpoint) as a reason for the reduction in the number of bees (which was also not observed in their studies). Because the study results did not support the authors' speculation about glyphosate effects on bees, this 2014 study provides no support to the hypothesis of behavioral deficit after exposure to glyphosate.

It should be noted that the term "sub-lethal effect" is often misused outside the scientific community. In the scientific context the term defines the effects of a stressor (pesticide in this case) that is less than mortality. It includes evaluation of the potential effects on physiological and behavioral systems that may occur over time or result in a deficit of a physiological function. Although important in the determination of the potential adverse impacts of the pesticide, it is the "endpoint" most susceptible to influence by confounding, outside, and environmental factors. Adverse effects that are categorized as sub-lethal are also often confused with the concept of chronic effects, which include low level effects that are continued over long periods of time and usually associated with constant exposures to a stressor. Because this condition (constant exposure to chemicals) is not typical of District vector control applications of the chemical glyphosate and other herbicides (generally single localized applications) and the insecticides (localized with some multiple applications) that do not produce constant exposures, it is not relevant to the evaluation of District use of pesticides.

The PEIR preparers have considered dozens of documents and studies related to glyphosate in evaluating the Program's potential impacts on ecological and human health. Furthermore, the author of the responses on pesticide use herein, both insecticides and herbicides, and the ecological and human health impact conclusions and related material in the Draft PEIR, is Bill A. Williams, PhD, a toxicologist with the educational and experiential background as an expert on pesticides and their use in aquatic and terrestrial environments. Dr. Williams has more than 30 years of experience and expertise in environmental risk assessment and toxicology, including CERCLA, NRDA, NEPA, and CEQA projects ranging from upland to sediment to freshwater/marine projects. Dr. Williams has been a member of numerous international, National Academy, and federal committees and workshops to define risk assessment guidelines, test procedures, field study approaches, and avian and mammalian test protocols, and to provide other technical assistance utilized by US EPA regulators. He helped develop US EPA's Framework for Ecological Risk Assessment and US EPA's risk assessment of 2,3,7,8 TCDD (tetrachlorodibenzo-p-dioxin or dioxin). He was a charter member of the Avian Dialogue Group, convened by the Conservation Foundation (RESOLVE) to bring industry, academia, and government regulators together to resolve conflicts between the groups. Dr. Williams has led and supported dozens of successful projects that were acceptable to the Washington Department of Ecology, Oregon Department of Environmental Quality, Oregon Department of Fish and Wildlife, US Environmental Protection Agency, Regions 2, 9, 10 and numerous other US EPA regions nationwide. Dr. Williams has served on several Oregon DEQ advisory science committees and workshops. He has been a member of several national and regional EPA Science Advisory Panels, including the National Science Advisory Panel on endocrine disruptors, uncertainty in risk assessments, and the panel on use of laboratory data in estimates of risk to wildlife.

The substantial evidence contained in the Draft PEIR and in the Final PEIR compiled by Dr. Williams and the best professional judgment exercised by Dr. Williams in the context of this CEQA evaluation of vector control is sufficient to support the PEIR's determination that impacts from glyphosate use under the Program would be less than significant.

Response 3

MCGP comments again on the WHO finding addressed in Response 1 above and suggests that those who oppose the findings are associated with the biotech industry. The PEIR preparers for the District are not associated with the biotech industry and are fully capable of exercising best professional judgment in

reviewing all of the studies on pesticides including glyphosate in an objective, technically defensible manner appropriate for the CEQA process. See Response 2 above for more information on the qualifications of Dr. Williams.

Response 4

The comments on use of glyphosate to reduce fire threats is not relevant to the District's PEIR. The District's use of glyphosate and other herbicides is for the management of vector habitat including the control of invasive weeds when these are problematic for vector control. The PEIR Chapter 8 Public Hazards is focused on the potential for District staff to access fire hazard areas and potentially ignite a fire from vehicle access. This potential hazard is minimized with BMPs included in the Program Description (Table 2-9):

> Equip all vehicles used in wildland areas with a shovel and/or a fire extinguisher during the fire season. (BMP J1)

> Train employees on the safe use of equipment and machinery, including vehicle operation. (BMP J2)

> District will regularly review and update the existing health and safety plan to maintain compliance with all applicable standards. Employees will be required to review these materials annually. (BMP J3)

> A hazardous spill plan will be developed, maintained, made available, and staff trained on implementation and notification for petroleum-based or other chemical-based materials prior to commencement of vector treatment activities. (BMP I5)

Response 5

Comments explaining the MCGP's values called "ecological wisdom" are noted and considered. Greenhouse gas emissions from the Proposed Program are addressed in Chapter 11. The District's energy requirements and conservation measures are described in Section 14.4 of the PEIR:

> "All equipment used in Program implementation would be kept up to date with maintenance requirements and would be used as efficiently as possible, i.e., minimize idling time of all vehicles and equipment; service and maintain all equipment according to manufacturer's instructions to remain in good working order; maintain vehicle tire pressure to manufacturer specifications; and inspect and reinflate tires at regular intervals, as stated in BMP A14 in Table 2-6." (page 14-2)

Response 6

The comment to use the precautionary principle is addressed in Response 1. Instead of eliminating all use of glyphosate, District staff believes it should be included in its Vegetation Management Alternative along with other herbicide options as appropriate, and thus has proposed to allow its use under the Proposed Program. However, the District has, for at least the past 2 decades, taken an integrated systems approach to mosquito and vector control, utilizing a suite of tools that consists of public education, surveillance, source reduction (e.g., physical control, vegetation management, water management), biological controls, and chemical controls. As stated in PEIR Section 2.3, three core tenets are essential to the success of a sound Integrated Vector Management Program (IVMP).

> First, a proactive approach is necessary to minimize impacts and maximize successful vector management. Elements such as thorough surveillance and a strong public education program make all the difference in reducing potential human vector interactions.

> Second, long-term environmentally based solutions (e.g., water management, reduction of harborage and food resources, exclusion, and enhancement of predators and parasites) are optimal as they reduce the potential pesticide load in the environment as well as other potential long- and short-term impacts.

> Lastly, utilizing the full array of options and tools (public education, surveillance, physical control, biological control, and when necessary chemical control) in an informed and coordinated approach supports the overall goal of an environmentally sensitive vector management program.

The District's integrated vector management approach seeks to protect human and animal health while minimizing environmental impacts.

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O-RRK

RUSSIAN RIVERKEEPER

October 1, 2015

Marin Sonoma Mosquito and Vector Control District
Board of Trustees
595 Helman Lans
Cotati, CA 94931

RE: Comments on MSMVCD PEIR on ESA issues raised by use of synthetic pyrethroids

Dear Board of Trustees,

Russian Riverkeeper ("RRK") is one of twelve California Waterkeeper organizations within the California Coastkeeper Alliance ("CCKA") network and a member of the international Waterkeeper Alliance. We represent our watershed community and our over 1600 members interest in the long-term health of the Russian River. As such we are gravely concerned with the lack of specific mitigations to ensure protection of ESA listed salmon habitat in the Marin Sonoma Mosquito and Vector Control District Integrated Vector Management Program Draft Programmatic PEIR (PEIR) dated August 2015. We have reviewed the PEIR and have the following comments to ensure the protection of water quality and Federal and State listed species of Salmon.

Significant Impacts to ESA listed Salmonids in the Russian River and tributaries:

- PEIR fails to adequately analyze potential impacts to ESA listed salmon from use of pyrethrin/pyrethroid class pesticides
- PEIR fails to adequately mitigate the potential impacts to ESA listed salmon through use of pyrethrin/pyrethroid class pesticides

1. Pyrethroids are persistent and bind with sediments and research has shown widespread presence of pyrethroids in benthic sediments at concentrations are acutely toxic to benthic organisms that are prey for salmon. [1,2,3,4] Pyrethroid use distant to streams still results in stormwater runoff that brings pyrethroids to streams.[5] Numerous existing sources of pyrethroids from urban and agricultural uses has resulted in elevated concentrations of pyrethroids in most waterways sampled. [6]

1

1. Laskowski DA: **Physical and chemical properties of pyrethroids.** Rev Environ Contam Toxicol. 2002;174:49-170. Available at: http://www.ncbi.nlm.nih.gov/pubmed/12132343
2. USEPA, 2011; Pyrethroiud Cumulative Risk Assessment; available at: http://www.regulations.gov/ - !documentDetail;D=EPA-HQ-OPP-2011-0746-0003
3. Use and toxicity of pyrethroid pesticides in the Central Valley, California, USA; Amweg, Erin L.; Weston, Donald P.; Ureda, Nicole M.; Environmental Toxicology and Chemistry (2005), 24 (4), 966-972 CODEN: ETOCDK; ISSN:0730-7268. (SETAC Press)
4. Weston, D.P., Holmes, R.W., Lydy, M.J. 2009. Residential runoff as a source of pyrethroid pesticides tourban creeks. Environ. Poll. 157:287 -294
5. See # 4
6. **Occurrence and Potential Sources of Pyrethroid Insecticides in Stream Sediments from Seven U.S. Metropolitan Areas**
Kathryn M. Kuivila*†, Michelle L. Hladik†, Christopher G. Ingersoll‡, Nile E. Kemble‡, Patrick W. Moran§, Daniel L. Calhoun‖, Lisa H. Nowell†, and Robert J. Gilliom†
Environ. Sci. Technol., 2012, 46 (8), pp 4297–4303

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O-RRK

Urban areas such as the Santa Rosa Plain are significant sources of pyrethroid at concentrations that are often acutely toxic to test species such as *H. Azetca* and was found to affect growth at concentrations below the LC50.[7,8] Macroinvertebrates and terrestrial insects make up the bulk of Coho Salmon that are listed as Endangered in the Russian River.[9] Freshwater macroinvertebrate species that are highly intolerant of pyrethroid concentrations at or below 1ug/L, such as Diptera, Amphipods & Oligochaeta comprise the majority of prey species for juvenile Coho Salmon.[10] In addition, Legacy toxicity from past use of pesticides such as DDT continue to persist in benthic sediments and this is often overlooked in risk assessments such as performed by this PEIR.[11] Use of pyrethroid class pesticides for the Project will diminish these food sources and impact ESA listed salmon contrary to the assertions in PEIR Section 4.2.7.1.2. 2

This PEIR and analysis of possible impacts from use of Mosquito Adulticides states in Section 4.2.7.1.2 that, "Numerous studies have found that these ULV applications result in concentrations in the aquatic environment of 0.23 to 3.77 µg/L and had little to no effect on fish or nontarget aquatic invertebrates (see Appendix B)." None of the studies listed considered additive effects from other pesticides, the severely degraded baseline for salmon habitat or the synergistic effects of legacy pesticides that could present significant un-mitigatable impacts.[12,13] 3

The Impact Analysis in Chapter 5 Biological Aquatic Impacts state on "Both sets of compounds tend to break down relatively quickly in the environment, often within hours, and usually within a few days", this is directly refuted by several research papers that show far longer half-life under certain conditions that are frequently present in the Russian river and tributaries such as the Laguna de Santa Rosa. According to the California Department of Pesticide Regulation, the half-life of Permethrin, is estimated at 51-240 days- this directly refutes the PEIR statement that is has no significant impacts due to Permethrin's short half life[14] Therefore any use of Permethrin is a significant impact to ESA listed Salmonid habitat and food sources well into winter months when juvenile fish lack adequate nutrition resources. 4

This PEIR is deficient in not properly analyzing potential significant impacts to ESA listed Salmon claiming no significant impacts, the PEIR additionally fails to mitigate those impacts and should not be approved or certified until the failures are remedied. 5

Noticing Issues for Relevant Public Agencies

First the list of State and Federal Agencies contacted on Page S-3 and S-4 doesn't contain the North Coast Regional Water Quality Control Board or the National Marine Fisheries Service and appears to indicate not all relevant agencies were contacted as required. The North Coast Waterboard is the regulatory agency for water quality impacts in over half of the project area. Additionally National Marine Fisheries Service – not USFWS – is the Federal Agency charged with implementing the Federal ESA with regards to Salmon and Steelhead which inhabit almost all of the project area which is common knowledge. Not contacting these agencies appears to be a significant omission from noticing all relevant agencies. 6

We strongly urge that the Board of Trustees use its discretionary authority to ban use of any pyrethroid class pesticide and associated synergists to avoid significant impacts to ESA Listed Salmonids in the Project Area. 7

Sincerely,

Don McEnhill
Executive Director

7. See #3 ibid

O-RRK

8. See #2 *ibid*
9. Diet and Prey Consumption of Juvenile Coho Salmon (Oncorhychus Kisutch) in three Northern California Streams, Gonzales, Eric, HSU, 2006; Available at: http://www2.humboldt.edu/cuca/documents/theses/gonzalesthesis.pdf
10. #9 *ibid*
11. The legacy of pesticide pollution: An overlooked factor in current risk assessments of freshwater systems; · Jes J. Rasmussena, , , Peter Wiberg-Larsena, Annette Baattrup-Pedersena, Nina Cedergreenb, Ursula S. McKnightc, Jenny Kreugerd, Dean Jacobsene, Esben A. Kristensena, Nikolai Friberg
12. *Ibid*
13. Factors Leading to Federal Listing (of Coho Salmon), NOAA Fisheries; available at: http://www.westcoast.fisheries.noaa.gov/publications/recovery_planning/salmon_steelhead/domains/north_central_california_coast/central_california_coast_coho/factors_i.pdf
14. Environmental Fate of Permethrin, Heather Imgrund, Environmental Monitoring Branch, Department of Pesticide Regulation, 2003

Comment Letter O-RRK — Russian Riverkeeper

Don McEnhill, Executive Director
October 1, 2015

Response 1

The commenter is concerned with the use of pyrethrins and pyrethroids and states that the Draft PEIR does not adequately address significant impact on salmonids, a special-status species. In short, Mr. McEnhill disagrees with the conclusions of the Draft PEIR and cites studies on these chemicals in support of his opinion.

The Draft PEIR evaluates this topic in several locations in the Draft PEIR text, which is based on the Appendix B, Ecological and Human Health Assessment Report, that discusses the toxicity and environmental fate and transport of the natural and synthetic pyrethroids. While we do not argue about the potential for these active ingredients to cause harm to nontarget species, including salmonids, the issue for the PEIR is whether the type of application, method of application, application rate, and the limited/targeted use of these chemicals by the District for vector control has the potential to cause a substantial adverse direct or cumulative impact to salmonids. The Draft PEIR also considers the context (environmental conditions) in which the District's use of pyrethrins and pyrethroids occurs in making a determination of significance under CEQA. For example, in covering the topic of water quality impacts in Section 9.2.7.2.1, the following information is provided:

> "Pyrethrins and pyrethroids quickly adsorb to suspended solids in the water column and partition into the sediment. They adsorb strongly to soil surfaces, and are generally considered immobile in soils and, therefore, are unlikely to leach to groundwater (USEPA 2006c). These materials are relatively nontoxic to mammals and birds, but are highly toxic to fish and invertebrates. The major route of degradation is through photolysis in both water and soil. Pyrethrins and pyrethroids may be persistent in environments free of light, and pyrethroids as a class have been implicated in 303(d) listings of sediment toxicity in urban creeks (BASMAA 2013). However, the ULV applications common to mosquito control and the limited use at ground-dwelling yellow jacket wasp nests (that pose an imminent threat to people or to pets) encourage dissipation rather than persistence in the environment.
>
> "Several studies have shown that pyrethrins applied using ULV techniques do not accumulate in water or sediment following repeated applications. These studies also determined that no toxicity is associated when exposure is limited to the amounts used when following ULV protocols for mosquito control (Lawler et al. 2008; Amweg et al. 2006). Pyrethrins would have a less-than-significant impact on surface water or groundwater, including their limited use near septic systems, when applied following District BMPs and using ULV techniques, and when used in accordance with label requirements and the District's PAP." (page 9-36)

Therefore, the concern that ULV applications of pyrethrin/pyrethroids for adult mosquito control and the very limited/focused use of it in nests of ground-dwelling yellow jacket wasps (in response to public service requests) would result in pyrethrin/pyrethroids being present in storm water runoff and subsequently in stream sediments is substantially overstated. The District's BMP H6 states: "Postpone or cease application when predetermined weather parameters exceed product label specifications, when wind speeds exceed the velocity as stated on the product label, or when a high chance of rain is predicted and rain is determining factor on the label of the material to be applied." Additional substantial evidence to support the PEIR's determination of a less-than-significant impact to surface water is presented below.

As noted in Section 9.1.2.1.1, *Section 303(d) Water Quality Limited Surface Waters* (page 9-9): This section requires each state to provide a list of impaired waters that do not meet or are expected not to meet state water quality standards as defined by that section. Note that the District is not proposing to use diazinon or any of the pesticides called out as contributing to impairment of surface waters under Section 303(d) within Marin and Sonoma counties.

As described in Section 9.1.2.2.8, the District operates under the Statewide NPDES Vector Control Permit but does not use all of the chemicals listed below:

> "The Statewide NPDES Permit for Biological and Residual Pesticide Discharges to waters of the US from Vector Control Applications (SWRCB Water Quality Order No. 2011-0002-DWQ with amendments; NPDES No. CAG 990004; Vector Control Permit) covers the point source discharge of biological and residual pesticides resulting from direct and spray applications for vector control. The District completed application requirements, including preparation of a Pesticide Application Plan (PAP) and public notice requirements, and received permit approval on October 31, 2011. Permitted larvicide active ingredients include monomolecular films, methoprene, *Bacillus thuringiensis* subspecies *israelensis* or Bti, *Bacillus sphaericus* or Bs, temephos, petroleum distillates, and spinosad. Permitted adulticide active ingredients include malathion, naled, pyrethrin, deltamethrin, lambda-cyhalothrin, permethrin, resmethrin, sumithrin, prallethrin, the synergist PBO, etofenprox, and N-Octyl bicycloheptene dicarboximide (MGK-264). The permit also includes language that allows adulticides and larvicides that are newly registered in California and that are based on active ingredients currently registered by CDPR to be used for vector control without having to further amend the permit. The permit contains a receiving water limitation for malathion and receiving water monitoring triggers for the other active ingredients. To obtain coverage under the permit, each discharger (typically a vector control district) must submit a Notice of Intent, application fee, and PAP, which is subject to approval by the SWRCB following a 30-day public comment period." (pages 9-13, 9-14)

Further support for the conclusions of less-than-significant impacts is provided in a 2-year monitoring study conducted for the State Water Resources Control Board by the Mosquito and Vector Control Association of California (MVCAC) monitoring coalition to determine whether vector control activities were contributing contaminants to State waters. The MVCAC monitoring coalition conducted chemical monitoring for adulticides at 61 locations during 19 application events in 2011 to 2012 and coordinated physical monitoring for 136 larvicide application events in 2012. Samples were collected from agricultural, urban, and wetland environmental settings in both northern and southern California. The adulticides evaluated included pyrethrin, permethrin, sumithrin, prallethrin, etofenprox, naled, malathion, and the synergist piperonyl butoxide. This monitoring study (MVCAC 2013) was conducted in accordance with the Statewide NPDES Vector Control Permit and had the following results:

> 1 out of 136 visual observations showed a difference between background and post-event samples;

> 108 physical monitoring samples showed no difference between background and post-event samples; and

> 6 out of 112 samples exceeded the receiving water monitoring limitation or triggers.

The report concluded that there was no significant impact to beneficial uses of receiving waters due to application of vector control pesticides in accordance with approved application rates. This is consistent with the primary mandate for vector control districts of protecting public health by reducing vector-borne diseases from mosquitoes and other vectors.

The State Water Resources Control Board evaluated the results of this study (MVCAC 2013) and a concurrent toxicity study conducted by researchers from UC Davis (Philips et al. 2013) and concluded that based on the monitoring data, the application of pesticides in accordance with approved application rates does not impact beneficial uses of receiving waters (SWRCB 2014). Therefore, the monitoring and

reporting program for the Statewide NPDES Vector Control Permit was amended in March 2014 to limit the required monitoring to visual observations, monitoring and reporting of pesticide application rates, and reporting of noncompliant applications (SWRCB 2014). The totality of the evidence indicates that the District's use of pyrethroid pesticides under the Program would not result in contamination of surface water or benthic sediments at levels that would cause toxicity to salmonids or salmonid prey, including benthic invertebrates.

Response 2

The commenter concludes that use of pyrethroid class pesticides will diminish a number of food sources (macroinvertebrates and terrestrial insects) that "make up the bulk of Coho Salmon that are listed as Endangered in the Russian River." Specific invertebrates are mentioned as comprising the majority of prey species for juvenile Coho Salmon.

The text in Section 4.2.7.1.2 includes the following:

> "Adulticides are applied from the ground via truck, ATVs, utility vehicles, or handheld devices as an ULV application.
>
> "Aerial adulticiding could be used in the future to deal with a severe outbreak or risk of mosquito-borne disease transmission. Aerial applications would be made using ULV techniques. Aerial application of adulticide may be the only reliable means of obtaining effective control in areas bordered by extensive mosquito production sites with a small, narrow, or inaccessible network of roads, or to cover a very large area quickly in case of unusually severe mosquito outbreaks or vector-borne disease epidemics. In making the decision to use this technique, the District considers the potential effects on human health and the potential for environmental harm. For example, the maximum application rate of an adulticide that could be used is 0.87 ounce/acre, although maximum application rates are generally not required. The concentration of the active ingredient is 5 percent or less of this volume. This translates into a water concentration of 1.04 µg/L if the water is one foot deep or 4.14 µg/L if the water is three inches deep. This assumes all of the product contacts the water. Aerial applications are made over vegetated areas preferred by adult mosquitoes, so the amount of product encountering the water is generally a fraction of this. The chemicals used are selected for rapid breakdown and are typically present for a few hours to a couple of days after application." (page 4-97)

What is critical to note here is that the bulk of any pyrethroid product applied over (as a fog) or near water would not contaminate the water because of the application method, and any resulting concentrations would be very low and not persistent. Because of the low frequency of applications and low concentrations of pyrethroids in the water column, the Program's use of pyrethroid pesticides would not have a substantial adverse effect on food supply for salmonids.

Terrestrial insects in flight at the time of a ULV application could be killed by the pyrethroid, along with the adult mosquitoes, who would then drop dead onto the surface of the water and potentially be eaten by juvenile salmon predators in these freshwater streams. An adverse effect to nontarget predators (food web transfer of applied chemical) would require the consumption of adequate numbers of contaminated pests to reach a concentration in the predator that would be toxic. In the food web constructs, predators consume prey items that are smaller in size and mass. This is the basis for the hierarchy inherent in the classical ecological food web. This process requires consumption of adequate numbers (mass) of contaminated prey items to exceed the dose known to result in adverse effects or mortality. To result in the bioaccumulation of chemical in an insect predator (including fish) sufficient to reach a level of sensitivity, the consumer species would have to consume very large numbers of contaminated insects. Given the specificity of pesticide toxicity to potential predators (see Table 6-1 in Appendix B of the PEIR), and the relative infrequency of District applications in any particular area, it would not be likely that

consumer species, including salmonids, would be adversely affected as a result of chemical transfer from the consumption of insects killed by Program use of pyrethroids.

The conclusion of the Weston et al. study (2015) further supports the PEIR's conclusion that properly selected pesticide applications can be effective against target mosquitoes while not resulting in unacceptable adverse impacts to nontarget species. The low levels of pesticides used by the District, combined with the careful application restrictions embodied in the District BMPs, results in the effective, yet environmentally compatible treatment for mosquitoes and other vectors. All pesticide applications are subject to several BMPs including the following:

> District will avoid use of surfactants when possible in sites with aquatic nontargets or natural enemies of mosquitoes present such as nymphal damselflies and dragonflies, dytiscids, hydrophilids, corixids, notonectids, and ephydrids. Surfactants are the only tool used to treat sources of pupae to prevent adult mosquitos' emergence. The District will use a microbial larvicide (Bti, Bs) or insect growth regulator (e.g., methoprene) instead or another alternative when possible. (BMP H2)

> Materials will be applied at the lowest effective concentration for a specific set of vectors and environmental conditions. Application rates will never exceed the maximum label application rate. (BMP H3)

Furthermore, the CEQA conclusions of less-than-significant impacts are based not only on the BMPs but on application methods (including methods recommended by the product label, which were developed through the product's EPA registration process to minimize adverse ecological impacts) and the concentration and type of chemical materials used. All of these factors, and including the physical context in which the applications occur (that subject the treatments to sunlight, air, and soil conditions that minimize persistence and facilitate breakdown) support the Draft PEIR conclusions that the effects are not substantial or adverse enough to be characterized as significant, i.e., a less-than-significant impact, not that there is a conclusion of zero or no impact. There could be a loss of some individual insects on occasion during an application of permethrin or pyrethroid product, but the loss would not be substantial for reasons cited above.

Response 3

The commenter is concerned about additive effects in the aquatic environment, the existing degraded salmon habitat conditions, and the synergistic effects of legacy pesticides. Another way of stating this is posing the question of "Is the District's ongoing use of pyrethroids under the Chemical Control Alternative interacting with other existing chemicals in surface water and sediments in a manner harmful to salmon?"

A study cited by the commenter was a thesis presented for partial fulfillment of a Master's degree and not a peer reviewed publication (Gonzales 2006). The objective of this unpublished thesis was to attempt to quantify the insect diets, caloric value, and estimates of prey consumption of salmon using computer modeling and some in-situ testing of selected streams in northern California. While the author provides some interesting information about the range of numbers of salmon (and biomass) in the testing segments of the rivers, he reports that the range varied considerably between test creeks, between years and months and ranged from an estimated 1.45 Coho salmon/m^2 to approximately 0.070 salmon/m^2 (approximately a 20 fold). Along with the salmon densities, he reports that the insect prey available also varied greatly. Gonzales further reports that the survival rates varied similarly from 9 to 75 percent across months and years evaluated. In his summary of his investigation, Mr. Gonzales suggests that "differences between summer and fall rearing potential arising from variation and availability of prey for juvenile Coho salmon bearing streams are likely secondary in importance to the amount of available winter habitat in regulating smolt production."

Because of this large variation in prey biomass, it is unlikely that impacts to prey items, regardless of the sources, would adversely impact the population of salmon in the streams and creeks used in the Gonzales study. For the reasons discussed in Response 2, the District's use of chemicals would not have the potential to remove sufficient prey so as to have a substantial adverse impact on salmonids.

Concerning additive or synergistic effects of pyrethroids with other materials the District could use, these materials are not applied at the same time. Section 6.2.2.2 contains the following discussion: "Concerning the application of multiple chemical treatments in the same area, such as larvicides followed by adulticides, or the application of multiple pesticides at the same time in a specific area, the following information applies:

> "Most products sold as herbicides and pesticides are evaluated herein both for the active ingredient and for the adjuvants and surfactants used to make the product more useful. When multiple products are used in a vector control application, the impacts are weighed against the proximity and timing of each application. When two approved products are used that contain two active ingredients, this scenario is possible, but the product usually already contains two active ingredients. If products with similar or even different active ingredients are applied simultaneously, it is likely that the net effect could be the sum of the effects of the active ingredients to impact the vector. However, for vector control applications materials with the same active ingredient are not applied to the same specific area simultaneously at a given site. The need for reapplication of mosquito larvicides or adulticides is surveillance driven and performed per the label directions. The District can apply larvicide materials with different active ingredients during a single application. This type of application is necessary if multiple hatches of mosquito larvae occur and results in mosquito populations occurring at different stages of the life cycle. An example of this occurs when liquid Bti and methoprene are applied simultaneously. When this occurs the combination of the material is a product called Duplex, and the mixture of the materials and active ingredients is provided for on the product labels. Another example, for the District includes a pre-application of a liquid trans allethrin and phenothrin spray product may be used to minimize the hazard of approaching a yellow jacket nest. Situations that would produce a residual exposure adequate to cause harm to humans would not occur unless the application(s) were inappropriate or the timing of applications is inappropriately close. Actual applications do not generally occur that close together unless there is a problem with treatment effectiveness. A material is applied followed by post treatment inspection to determine effectiveness. Only if the vectors (mosquitoes) have not been sufficiently killed would the District go back into the area and reapply a pesticide." (Page 6-15)

The question is more appropriately a cumulative impact concern about the District's use of pesticides in combination with pesticides used by others (including homeowner use involving liquid spray and granular products; agricultural use on row crops, vines, and trees; and past/present/future use) that have affected surface waters and potentially aquatic species such as salmon. The Draft PEIR discusses the issue of pelagic organism decline in Section 13.2.1.2 and concluded that the Chemical Control Alternative does not contribute substantively to chemical loads in salmonid habitats. This conclusion is supported by the 2 years of monitoring work done under the Statewide NPDES Vector Control Permit, described under Response 1 above. While overall use of pesticides throughout the Program Area may be considered cumulatively significant, the District's incremental contributions to this impact are not cumulatively significant given use of District BMPs and permit requirements.

There are many confounding factors contributing to the decline of salmon, and pesticides may be one of these factors, especially where discernible amounts have been documented leading to water quality impairment of specific water bodies. However, for the reasons stated in the PEIR and these responses to comments, the District is not having an individually significant impact or cumulatively considerable contribution to impacts to salmonids, which may be caused by other pesticide users as well as other environmental factors such as ocean conditions, access to habitat and streamflows.

Response 4

The commenter argues that persistence of pyrethroids in the environment specifically its “half-life” is greater than that that cited in the PEIR, based on local conditions in the Russian River and CDPR data.

Although the commenter suggests that the half-life of permethrin is greater in the region of the Russian River, the commenter has not provided monitoring or sampling information to validate the claim that it is different from the published literature. Without providing the necessary detailed and appropriate monitoring data, the permethrin half-life in the Russian River watershed should be assumed to track the published data and USEPA-designated chemical and environmental characteristics. Since the comment does not identify the “certain conditions that are frequently present in the Russian River and tributaries” to result in longer half-lives, so a more specific response is not possible.

By design, few chemicals used as pesticides have half-lives greater than a week and are further degraded by the environmental conditions of the application area. When pesticides get into soil, or water, or are taken up by plants and animals, the half-life characteristics are altered. The environmental fate of pesticides depends on the physical and chemical properties of the pesticide, particularly the pH of the medium, modifying how likely it is to travel through soil (soil mobility), how well it dissolves in water (water solubility), and how likely it is to become airborne (volatility) (USEPA 1993). From several sources of data relating the half-life of pyrethroids, although there are numerous ranges reported, a reasonable estimate of the half-life as published by USEPA and the National Pesticide Information Center (NPIC), should be approximately 12 to 13 hours in water and soil surfaces. While these are typical values, the range of half-life values reported for pyrethroids can range from a few hours to days or weeks because the half-life is dependent on the physiochemical characteristics of the media to which it is applied (pH, temperature etc.). The process of degradation is driven primarily by sunlight and other exogenous factors, but these values provide a defensible basis for a typical estimate of half-life under most conditions (National Pesticide Information Center 2014). The reported longer half-life values are generally associated with a lack of sunlight

More important considerations in the evaluation of the possible impacts of the use of pyrethroids by the District are the following:

1. The applications are conducted using ULV techniques that employ very low concentrations (considerably lower than urban or agricultural uses) of chemical applied to focused sites using BMPs designed to further reduce the likelihood of chemical exposure to unwanted areas;
2. The contribution of chemicals, including pyrethroids, is substantially greater from agricultural sources than all others. Evaluation of the pyrethroid concentrations in field studies must acknowledge the individual, specific sources; and
3. Laboratory studies relating the toxicity of pyrethroids to test species provide the basis for relative sensitivity and toxicity and it is clear that the concentrations required to result in toxicity to salmon are substantially higher than the likely chemical concentrations reaching waterways potentially affected by Program use. This was verified in a study conducted in situ to evaluate the potential adverse effects of pyrethroids reaching the river watershed in which mortality and sublethal effects to salmon were not observed (Wilson et al. 2015).

The best available evidence supports the PEIR’s determination that the District’s use of pyrethroid pesticides would not have a significant impact on salmonids, and the commenter has not provided any evidence that would refute that determination.

Response 5

The comment is that the Draft PEIR is deficient because it did not properly analyze potential significant impacts to ESA listed salmon and fails to mitigate these impacts.

The PEIR preparers considered substantial evidence in preparing the Draft PEIR, including studies on the effects of pyrethroids that were evaluated in the context of the material's application procedures and concentration to be effective for vector control along with District BMPs. The PEIR preparers considered the comments and studies cited by Mr. McEnhill in the responses above, which conclude the comments provide no relevant information about impacts to salmonids or salmonid prey that could be linked to District activities.

The Draft PEIR's conclusion that pyrethroid use by the District for vector control does not have significant impacts on salmon remains unchanged. Clearly, there is public controversy over the issue of pesticide use, and specifically the pyrethroids of concern to RRK. There is a difference of opinion between the commenter and the Draft and Final PEIR conclusions of less-than-significant impact. The additional information evaluated in the process of addressing these comments does not refute conclusions of less-than-significant impact and does not invalidate the PEIR or require recirculation of the PEIR.

The Draft PEIR correctly analyzed the impacts associated with the District's Proposed Program, and additional information is provided herein to support the original conclusions as well as document consideration of information provided by the commenter. The information above provides clarification of material contained in the PEIR and addresses specific questions raised in comments for this Final PEIR. None of the comments identified substantial evidence of a new significant impact that was not considered in the Draft PEIR, and no Draft PEIR impacts need to be changed from less-than-significant to significant; thus a recirculated Draft PEIR is not required. Disagreement among experts is not a sufficient reason to invalidate conclusions reached by technical experts involved in EIR preparation.

The technical qualifications of all of the preparers of the District's PEIR are summarized in Chapter 16, Preparers. Furthermore, the principal author of the responses on pesticide use herein, both insecticides and herbicides, and the ecological and human health impact conclusions and related material in the Draft PEIR, is Bill A. Williams, PhD, a toxicologist with over 30 years of experience and the educational and experiential background as an expert on pesticides and their use in aquatic and terrestrial environments. A summary of Dr. Williams' qualifications to evaluate the scientific literature and to consider where and how the pesticides are being used specifically by the District for vector control, in order to draw conclusions of impact significance to humans and to nontarget species, are provided below. The highlights of his extensive experience presented are from Dr. Williams' technical resume.

Dr. Williams has more than 30 years of experience and expertise in environmental risk assessment and toxicology, including CERCLA, NRDA, NEPA, and CEQA projects ranging from upland to sediment to freshwater/marine projects. Dr. Williams has been a member of numerous international, National Academy, and federal committees and workshops to define risk assessment guidelines, test procedures, field study approaches, and avian and mammalian test protocols, and to provide other technical assistance utilized by US EPA regulators. He helped develop US EPA's Framework for Ecological Risk Assessment and US EPA's risk assessment of 2,3,7,8 TCDD (tetrachlorodibenzo-p-dioxin or dioxin). He was a charter member of the Avian Dialogue Group, convened by the Conservation Foundation (RESOLVE) to bring industry, academia, and government regulators together to resolve conflicts between the groups. Dr. Williams has led and supported dozens of successful projects that were acceptable to the Washington Department of Ecology, Oregon Department of Environmental Quality, Oregon Department of Fish and Wildlife, US Environmental Protection Agency, Regions 2, 9, 10 and numerous other USEPA regions nationwide. Dr. Williams has served on several Oregon DEQ advisory science committees and workshops. He has been a member of several national and regional EPA Science Advisory Panels, including the National Science Advisory Panel on endocrine disruptors, uncertainty in risk assessments, and the panel on use of laboratory data in estimates of risk to wildlife.

Of particular relevance to his role on the CEQA documents for mosquito and vector control agencies is that Dr. Williams recently provided strategic and scientific support in the development of an Integrated Pest Management (IPM) system for use by the Mid-Peninsula Open Space District in the San Francisco Bay Area. The IPM is tailored to the vectors of concern, the pesticides and herbicides used by the District, and potential risk to the nontarget aquatic and terrestrial species. Pesticides incorporated into the IPM were based on evaluations of the use of more than 20 herbicides (with emphasis on use of glyphosate in regional wildland areas for control of over 60 invasive plant species), dozens of insecticides, structural and nuisance agricultural and urban pests, and selected regional wildlife pests. The IPM developed for the District included control of ants, cockroaches, wasps and flies, ticks, and mosquitoes. The IPM plan included recommendations for establishing and conducting pest identification, conducting damage assessments, and establishing tolerance levels and several tiers of proposed vector control that addressed top to bottom elements of implementation strategies.

Dr. Williams also provided scientific reviews and risk assessments addressing the potential adverse effects of CAL FIRE herbicide use to reduce the potential for and mitigation of wildfires in California. The Vegetation Treatment Program (VTP) project included evaluation of potential adverse impacts of herbicides used in forestry and rangeland to control brush and grasses and for maintenance of areas that have been previously cleared of heavy vegetative fuels. The primary herbicides of concern in the evaluation were the numerous products containing glyphosate as the active ingredient.

Dr. Williams has participated in numerous workshops as a speaker or panel member on ecological risk assessment addressing such topics as uncertainty analysis in ecological risk assessments, ecotoxicological principles for avian field studies, population ecology and wildlife toxicology of agricultural pesticide use, and environmental effects assessment. He has published numerous peer-reviewed studies in scientific journals and presented abstracts in scientific meetings, including the following (of more than nine book chapters, 55 peer reviewed studies and more than 105 meeting abstracts):

> Williams, B.A., J.Q. Word, and W. Gardiner. 2007. Detecting the Presence and Effects of Pharmaceuticals and Personal Care Products in Water Samples. WEFTEC Annual Conference October 11-17 September, 2007. San Diego, CA.

> Williams, B.A., J.Q. Word, and W. Gardiner. 2007. Reducing Effects of Endocrine Disrupting Compounds: Effluent Blending. WaterReuse Assoc. Conference July 29-30, 2007. Providence, RI.

> Williams, B.A., L.J. Kennedy, J.A. Nedoff, and T. Fuji. 2005. “Risk Assessment as a Tool for Emerging Contaminants and Water Quality Decisions.” PNW AWWA Meeting, Portland, OR, 4-6 May 2005.

> Bahe, A., B.A. Williams, L.J. Kennedy, and J.A. Nedoff. 2004. “Do Residual Levels of Pharmaceuticals Contribute to Endocrine Disruption?” 25th Annual Mtg. SETAC, Portland, OR, 14-18 November 2004.

> Williams, B.A., L.J. Kennedy, and J.A. Nedoff. 2003. “Uncertain About Uncertainty in Environmental Risk Assessment.” NorCal SETAC, Berkeley, CA, 6-7 May 2003.

> Kapustka, L.A., B.A. Williams, and A. Fairbrother. 1996. “Evaluating Risk Predictions at Population and Community Levels in Pesticide Registration - Hypotheses To Be Tested.” Environ. Toxicol. & Chem. 15(4), 427-431.

> Williams, B.A., et al. 1994. “Assessing Pesticide Impact in Birds. Final Report of the Avian Effects Dialogue Group (1988-1993).” Resolve, 156 pp., Washington, DC.

> Williams, B.A., et al. 1991. “Assessing Pesticide Impact in Birds. Discussions of the Avian Effects Dialogue Group (1989–1991).” Resolve, Washington, DC.

The substantial evidence contained in the Draft PEIR and in the Final PEIR compiled by Dr. Williams and the best professional judgment exercised by Dr. Williams in the context of this CEQA evaluation of vector control alternatives is defensible and sufficient.

Response 6

The North Coast Regional Water Quality Control Board received the NOA and the Draft PEIR on CD from the State Clearinghouse. The National Marine Fisheries Service office in Santa Rosa was on the PEIR mailing list for the NOA and was included in the list of federal agencies in Section 1.4.4. The list included in the Summary was of state responsible and trustee agencies only.

Response 7

The District's Proposed Program is an IVMP. District policy is to identify those species that are currently vectors, to recommend techniques for their prevention and control, and to anticipate and minimize any new interactions between vectors and humans and domestic animals. The District's IVMP employs integrated pest management (IPM) principles by first determining the species and abundance of mosquitoes/vectors through evaluation of public service requests and field surveys of immature and adult mosquito/vector populations and, then, if the populations exceed treatment guidelines, using the most efficient, effective, and environmentally sensitive means of control. This approach minimizes the potential for chemical use. Based on the experience and technical knowledge of District staff, pyrethroids are an important option for use to control adult mosquitoes; and based on the information contained in the PEIR, they can be used without a significant impact on salmonids. The District's Board will consider these and other comments prior to certifying the PEIR and then deciding on the Program to approve for implementation.

Additional References

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October 2, 2015

Via Email

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Re: Comments on Marin and Sonoma Mosquito and Vector Control District Integrated Vector Management Program Draft Programmatic Environmental Impact Report; State Clearinghouse No. 2012052066

Dear Mr. Smith:

On behalf of Pesticide Free Marin by 2016, Turning Green, Coast Action Group, Sustainable TamAlmonte, and Mary Fraser we submit the following comments on the Draft Programmatic Environmental Impact Report ("DPEIR") for the Marin and Sonoma Mosquito and Vector Control District's ("MSMVCD's") Integrated Vector Management Program, prepared pursuant to the California Environmental Quality Act, Public Resources Code §§ 21000 *et seq.* ("CEQA").

PROJECT DESCRIPTION

CEQA requires than an EIR include "an accurate, stable and finite project description" for the action being reviewed. *County of Inyo v. City of Los Angeles* (1977) 71 Cal.App.3d 185, 192; California Code of Regulations, Title 14 ("Guidelines") § 15124. "A curtailed or distorted project description may stultify the objectives of the reporting process. Only through an accurate view of the project may affected outsiders and public decision-makers balance the proposal's benefit against its environmental cost, consider mitigation measures, assess the advantage of terminating the proposal (i.e., the 'no project' alternative) and weigh other alternatives in the balance. An accurate, stable and finite project description is the *sine qua non* of an informative and legally sufficient EIR." *County of Inyo* at 192-193. The project description for the Integrated Vector Management Program ("Program") fails to satisfy CEQA's requirements in numerous ways.

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For example, CEQA mandates that the DPEIR identify the "precise location and boundaries of the proposed project . . . on a detailed map," yet the DPEIR entirely fails to do so – in both the text and on the provided map. Guidelines § 15124(a); DPEIR 2-1, 2-3. As the DPEIR admits, "the Program occurs in an area that is somewhat larger than the District's Service Area," because of the "potential for control activities within the Service Area to affect any adjacent jurisdictions." DPEIR 2-1. But the DPEIR fails to disclose what this larger "Program Area" comprises. *Id*. The adjacent jurisdictions are sizeable and the DPEIR fails to specify what portions of these adjacent counties comprise the Program Area. DPEIR 2-1. Indeed, the "Program Area " map provided as Figure 2-1 does nothing to shed light on this significant failure. DPEIR 2-3. This map identifies the "Service Area" and "adjacent counties" only: Again, there is no identification or depiction of the Program Area. 1

The description of the proposed Program activities also fails to pass CEQA muster. DPEIR S-5 to S-8, 2-5 to 2-41; Guidelines § 15124. The DPEIR describes the Program components as "Program alternatives." DPEIR S-5. 2-5 to 2-41. However, "alternatives." are a CEQA term-of-art used to describe potential activities that can be implemented *instead* of the Program to lessen significant impacts. Guidelines § 15126.6. Here, the Program activities are optional components of the Program, not alternatives to the Program as a whole. *Id.* CEQA alternatives to the entire Program are presented – albeit insufficiently – via the Reduced Chemical Control Alternative, the No Chemical Control Alternative, and the No Project Alternative. DPEIR 2-49 to 2-52, 15-2 to 15-8; Guidelines § 15126.6. The project components that the DPEIR erroneously terms "program alternatives," are actually just parts of the Program itself. DPEIR 2-5. The DPEIR's description of "Program 'tools' or components . . . as 'Program alternatives' for the CEQA process" is inaccurate, confusing and misleading. 2

Further, the Project Description indicates that existing Best Management Practices ("BMPs") will be used to reduce what would otherwise be potentially significant impacts caused by the Program. DPEIR S-5, 2-54. Again, the DPEIR misuses a CEQA term-of-art, creating an inaccurate and unstable project description. *Id*. Under CEQA, mitigation "describe[s] feasible measures which could minimize the significant adverse impacts" of a project. Guidelines § 15126.4(a)(1). The BMPs identified in the DPEIR are actually mitigation measures donning a false identity. As defined by the DPEIR, the BMPs are "measures to avoid, minimize, eliminate, rectify, or compensate for potential adverse effects." DPEIR 2-54. This is *exactly* what mitigation measures are supposed to do. Guidelines § 15370 (defining mitigation to include "[a]voiding," "[m]inimizing," "[r]ectifying," "[r]educing," "eliminating," or "[c]ompensating" adverse impacts). As mitigation measures, the BMPs violate CEQA because they are unenforceable and vague. Guidelines § 15126.4(a)(2). By analyzing these actions as BMPs rather than mitigation measures, the DPEIR undermines an accurate analysis of the Program's 3

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impacts, alternatives, and the applicability and effectiveness of mitigation measures *throughout the DPEIR*. *See* DPEIR §§ 3.2, 4.2, 5.2, 6.2, 7.2, 8.2, 9.2, 10.2, 11.2, 12.2, 13. The DPEIR's failure to adequately describe the Program sabotages the entire DPEIR analysis. 3

The DPEIR also treats the educational aspect of the Program as exempt from CEQA, but it is improper to segment a project into smaller pieces to avoid CEQA review. DPEIR 2-5, 2-41, 2-43; *Sierra Club v. West Side Irrigation District* (2005) 128 Cal.App.4th 690, 698 ("A public agency may not divide a single project into smaller individual projects in order to avoid its responsibility to consider the environmental impacts of the project as a whole"); Guidelines §§ 15165, 15378. If the educational aspect of the Program is part of the Project under review, it should be considered comprehensively in the DPEIR. 4

RANGE OF ALTERNATIVES

By conflating BMPs and mitigation measures, and thereby understating the Program's impacts, the DPEIR also fails to consider a reasonable range of alternatives that could minimize the Program's yet-unknown impacts. Guidelines § 15126.6. The two action alternatives that were considered – Reduced Chemical Control and No Chemical Control – are insufficient to address the numerous impacts that have not been adequately analyzed in the DPEIR, as discussed in more detail below. For example, the DPEIR must also consider alternatives that reduce the significant Program impacts to biological resources and water quality. Pub. Res. Code § 21002; Guidelines § 15126.6. Like the remaining sections of the DPEIR, the alternatives analysis is undermined by the failure to adequately describe and analyze the Program. 5

IMPACT ANALYSIS

I. Biological Impacts

A. Pollinators

The Program's chemical control components include pesticides that harm pollinators. The use of spinosad and pyrethroid-type insecticides (including but not limited to synthetic pyrethroids, permethrin, resmethrin, and etofenprox) directly imperils the health of these beneficial insects. Further, the vegetation management component's use of glyphosate has been shown to have sub-lethal effects on the European honeybee.[1] The DPEIR fails to properly account for the Program's pesticide-based pollinator impacts. 6

[1] Lucila T. Herbert, Diego E. Vázquez, Andrés Arenas and Walter M. Farina, *Effects of field-realistic doses of glyphosate on honeybee appetitive behaviour*, JOURNAL OF EXPERIMENTAL BIOLOGY 217, 3457-3464 (October 2014).

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The DPEIR incorrectly assumes that BMPs it proposes will prevent *any* significant impacts to pollinators. But this assumption is flawed. First, these BMPs are mainly targeted at domestic honeybees, yet wild bees, moths, butterflies, and flies are important insect pollinators in MSMVCD's service area.[2] *E.g.* DPEIR 6-14 (BMP prevents applications over 0.25 acres "during day when honeybees are present and active or when other pollinators are active," with application instead "in areas with little or no honeybees or pollinator activity or after dark"). Yet many pollinating moths are active at night and would be subject to spraying under this BMP. The DPEIR must address this potentially significant impact. 7

Second, the DPEIR erroneously assumes that visual inspection prior to application will prevent post application harms. The DPEIR fails to acknowledge that pesticide residues will *remain* in toxic amounts for days or even weeks, endangering non-target insects long after application ceases. 8

Third, the DPEIR only addresses acute impacts of glyphosate use and assumes that it will have no impact on pollinators. DPEIR 5-50 to 5-51. Consequently, the BMP claiming that the Program "do[es] not apply pesticides that could affect insect pollinators . . . over large areas" does nothing to prevent the application of herbicides like glyphosate while pollinators are present. By ignoring the sub-lethal impacts of glyphosate, the DPEIR fails to account for all pathways and methods of harm to pollinating insects, and fails to mitigate those harms. 9

Each of these deficiencies must be corrected in a recirculated DPEIR. 10

B. Special Status Aquatic Species

The Program's chemical control components envision the use of a wide variety of pyrethroid type insecticides (including but not limited to synthetic pyrethroids, permethrin, resmethrin, and etofenprox) that are extremely toxic to aquatic species. Further, because these chemicals bind to soil, they accumulate in benthic sediment at levels known to be toxic to benthic invertebrates. Thus, their presence in the watershed poisons the bottom of the aquatic food-chain. Special precautions are necessary to ensure that these chemicals are not introduced into the aquatic environment, including wide buffers around storm-drains, drainage channels, and water bodies. Yet MSMVCD contemplates that its application of these chemicals to target mosquito adults *will* cause these toxics to enter water bodies. *E.g.* DPEIR 4-97 ("the amount of product encountering the water" is less than the total amount applied). 11

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[2] Janis Mara, *Marin volunteers stalk the wild pollinator on UC Extension's 100th birthday*, MARIN INDEPENDENT JOURNAL (May 8, 2014), available at http://www.marinij.com/general-news/20140508/marin-volunteers-stalk-the-wild-pollinator-on-uc-extensions-100th-birthday. Hummingbirds and bats also serve this important function. *Id.*

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MSMVCD's service area is important habitat for fish species listed as threatened or endangered under the Endangered Species Act ("ESA"), 16 U.S.C. section 1531 *et seq*., and the California Endangered Species Act, Fish and Game Code sections 2050-2115, including but not limited to coho salmon, chinook salmon and steelhead.[3] 12

None of the BMPs specify the types of precautions necessary to prevent these classes of pesticides from entering the watershed. As such, the BMPs alone cannot prevent significant harm to special status aquatic species – through direct exposure and through the loss of prey and prey habitat – in MSMVCD's service area. The DPEIR's mistaken decision to ignore food-chain impacts (DPEIR 4-74 to 4-75, 5-37 to 5-38, 6-16) exacerbates its failure to address the chemical control component's significant effects on threatened and endangered salmonids and other special status fish species. 13

Lastly, the chemical control component contemplates the use of methoprene – an insect growth regulator – that it acknowledges is moderately toxic to fish and highly toxic to aquatic invertebrates. DPEIR Appendix B, 4-5. This chemical is applied to water bodies to alter the growth and development of mosquito larva, rendering them unable to mature. *Id.* The DPEIR mentions in passing that methoprene is potentially bioaccumulative. DPEIR 5-60. But it does not explain how applying a potentially bioaccumulative, toxic chemical to water will have no significant impacts to aquatic species. Absent any contrary explanation, logic dictates the opposite result. 14

The DPEIR's incorrect assumptions that the BMPs presented in Table 4-6 will suffice to prevent any harm, and that its use of these pesticides will not cause significant impacts, must be corrected with an accurate discussion of the harms that these chemicals will cause, and an explanation of how mitigation measures will avoid any significant effects. 15

C. California Red-Legged Frog

EPA evaluated whether permethrin is likely to impact both the aquatic and terrestrial phases of the California red-legged frog, which is listed as a threatened species under the ESA. EPA determined that permethrin *directly* kills California red-legged frogs during aquatic and terrestrial life-phases, and *indirectly* impacts them by killing both aquatic and terrestrial sources of prey.[4] Further, EPA determined that the use of permethrin would likely modify critical habitat 16

[3] The DPEIR's narrative discussion of the impacts on special status species improperly omits coho salmon, although it is properly included in the chart of species present in the service area.

[4] http://www.epa.gov/espp/litstatus/effects/redleg-frog/permethrin/determination.pdf (Last visited September 30, 2015).

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for the California red-legged frog. *Id.* EPA likewise evaluated the impacts of glyphosate on the California red-legged frog, and determined that it is likely to adversely affect the terrestrial phase through direct and indirect effects following a reduction in prey and habitat, and is predicted to modify the critical habitat.[5] The Recovery Plan for the California red-legged frog,[6] which indicates that Roundup-brand glyphosate contains surfactants that are much more hazardous that glyphosate alone, raises concerns that its use near California red-legged frog habitat should be prohibited. 17

The DPEIR acknowledges that use of many of the pesticides associated with its chemical control and vegetation management components would be subject to an injunction to prevent harm to the California red-legged frog, but for the Program's purpose of vector control. DPEIR 4-42. But whether the vector control purpose exempts the MSMVCD from this injunction is a *separate* issue from whether the Program is likely to have a significant impact on the California red-legged frog. The DPEIR should present a clear examination of these risks. 18

Instead of addressing this issue, however, the DPEIR assumes that the BMPs presented in Table 4-6 will suffice to prevent any harm, and that its use of these pesticides will not cause significant impacts. *See e.g.* DPEIR 4-52 to 4-54, 4-75, 4-104. Just as with special status fish species, however, none of these BMPs adequately address and prevent run-off, through storm drains or otherwise, to protect the California red-legged frog from pesticide exposures. The DPEIR explicitly acknowledges that MSMVCD's territory includes California red-legged frog habitat. Its failure to specifically address and mitigate potentially significant impacts to this species must be corrected. 19

D. Ecological Health and Glyphosate

On July 7, 2015, the Marin Municipal Water District ("MMWD") "Board of Directors were given a standing ovation by a packed room of residents after they voted to approve Staff's recommendation to remove herbicides from further consideration in MMWD's DRAFT Wildfire Protection and Habitat Improvement Plan." Sharon Ruston, *The Marin Post, MMWD Board of Directors Votes to Remove Herbicides From Further Consideration!*, July 8, 2015.[7] It did so 20

[5] http://www.epa.gov/espp/litstatus/effects/redleg-frog/glyphosate/transmittal-ltr.pdf (last visited September 30, 2015).

[6] U.S. Fish and Wildlife Service, Recovery Plan for the California Red-legged Frog (May 2002) pp. 122-123. https://www.fws.gov/arcata/es/amphibians/crlf/documents/020528.pdf (last visited September 30, 2015).

[7] Available at https://marinpost.org/blog/2015/7/8/mmwd-board-of-directors-votes-to-remove-herbicides-from-further-consideration (as visited October 1,

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both due to community opposition and because the World Health Organization recently classified glyphosate as a probable human carcinogen. *See id.* 20

Glyphosate threatens human health and environmental harm in several ways ignored by the DPEIR.[8] Glyphosate is extremely persistent, and can be detected at application levels months after application. Because glyphosate attacks the ability of plants and bacteria to synthesize aromatic amino acids, Monsanto has patented its use as an antimicrobial agent; its use interferes not only with target plants but also with soil bacteria (and bacteria inside anything that accidentally ingests its residue).[9] Healthy soil bacteria should be preserved, not jeopardized by glyphosate.[10] Yet the DPEIR does not mention these significant ecological risks in its discussion of the vegetation management component. 21

The DPEIR also downplays glyphosate's risks to human health. In March 2015, the World Health Organization's International Agency for Research on Cancer ("IARC") determined that glyphosate is "probably carcinogenic to humans."[11] It is suspected to cause miscarriages and abnormal fetal development, promote cell growth in breast-cancer cells, impact hormone levels, and interfere with cytochrome P450 oxidase in the intestine and liver, and can impair the normal balance of intestinal microbes. The DPEIR's failure to consider these potentially significant human health risks must be corrected. 22

2015).

[8] Indeed, given glyphosate's toxicity, it is possible that an unintended consequence of its use will be an increase in mosquitos in MSMVCD's service area, as it *removes mosquito predators* from the food-chain.

[9] N. de María, et al., New insights on glyphosate mode of action in nodular metabolism: Role of shikimate accumulation, *J. Agric Food Chem.* (April 5, 2006) 54(7):2621-8; Monsanto Technology LLC, Missouri. Glyphosate formulations and their use for the inhibition of 5-enolpyruvylshikimate-3-phosphate synthase. 2010. US Patent number 7771736 B2. https://www.google.com/patents/US7771736.

[10] *See e.g.* McNear Jr., D. H. (2013) The Rhizosphere - Roots, Soil and Everything In Between. *Nature Education Knowledge* 4(3):1 (at the discussion of "Plant Growth Promoting Rhizobacteria (PGPR)"). Available at: http://www.nature.com/scitable/knowledge/library/the-rhizosphere-roots-soil-and-67500617 [accessed October 1, 2015].

[11] *See* Joint FAO/WHO Meeting on Pesticide Residues (JMPR). Available at: http://www.who.int/foodsafety/areas_work/chemical-risks/jmpr/en/ [accessed October 1, 2015].

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II. Water Quality

Many of Marin and Sonoma County's watersheds are impaired for pesticides, and as the DPEIR acknowledges, the Basin Plan establishes a total maximum daily load ("TMDL") for pesticide-related toxicity in urban creeks that is *not* specific to any particular pesticide. DPEIR 9-12 to 9-13. However, the DPEIR fails to explain how the chemical control and vegetation management components avoid exceeding the TMDL. Indeed, as discussed above, the BMPs fail to establish a clear buffer for storm drains and gutters or provide specific discussion of ways that run-off will be avoided. For chemicals that bind to the soil, the DPEIR fails to address the mobilization of sediment after pesticide applications. Further, the DPEIR fails to discuss with any clarity the potential quantity and concentrations of pesticides that could be used under the chemical control or vegetation management components. The DPEIR's claims that the BMPs will prevent significant water quality impacts are unsupported and incorrect. 23

III. Air Quality

The DPEIR admits that the Chemical Control component of the Program "could be *potentially significant*" because it "could subject people to objectionable odors." DPEIR 10-32, emphasis in original. Yet it erroneously claims that a single voluntary and unenforceable mitigation measure would "reduce the impact to less than significant." DPEIR 10-32, emphasis omitted. CEQA requires more. The DPEIR must analyze and implement *feasible* and *effective* mitigation measures to reduce these air quality impacts. § 21002; Guidelines § 15126.4.

Mitigation measures AQ-25a, AQ-25b, and AQ-25c are neither mandatory nor effective. DPEIR 10-32. This failure must be remedied. For example, the DPEIR could strengthen the individual mitigations, and *require* implementation of "any one of" the three where application of a malodorous chemical occurs within a certain distance of residences or human population centers. The DPEIR could also require notification to residences and offer resources for those who will be impacted. In any event, the DPEIR must do more to mitigate this impact than the vague, voluntary, and unenforceable mitigation measures it currently proposes. DPEIR 10-32. 24

Furthermore, the voluntary and vague nature of mitigation measures AQ-25a, AQ-25b and AQ-25c conflicts with the DPEIR's "less than significant" conclusion, and any future reliance on that conclusion. DPEIR 10-32. As discussed below, MSMVCD must either commit to preparing EIRS for future Program activities, or include much greater specificity now. Without greater specificity, MSMVCD cannot presume that air quality impacts will be mitigated now, or during implementation of future site-specific Program activities.

IV. Cumulative Impacts

The DPEIR's cumulative impacts analysis is plagued by many of the same defects as the 25

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remainder of the DPEIR. DPEIR 13-1 to 13-19. Again, the DPEIR's conflation of BMPs and mitigation measures makes it impossible for decisionmakers and the public to understand the severity of the Program's cumulative impacts and subsequently, the potential for and effectiveness of any mitigation measures. *Environmental Protection Information Center, Inc. v. Johnson* (1985) 170 Cal.App.3d 604, 625; *County of Inyo*, 71 Cal.App.3d at 192; Guidelines §§ 15130, 15355; DPEIR 13-1. 25

Many of the DPEIR's resource-specific cumulative impact analyses are also deficient. For example, the DPEIR's discussion of the Program's cumulative impacts on pollinators suffers from several serious flaws. First, it contains a largely irrelevant and factually inaccurate discussion of colony collapse disorder's association with neonicotinoid pesticides when it should instead be focusing on the contribution of the Program's chemical use to the existing decline in pollinator populations. DPEIR 13-8. The DPEIR attempts to shift the focus from the cumulative impacts of pesticides on pollinators to a discussion on whether neonicotinoid pesticides cause colony collapse disorder instead of simply killing bees. DPEIR 13-8. But whether a study on colony collapse disorder can be replicated is irrelevant to the questions whether neonicotinoid pesticides *harm* bees and whether the Program has cumulative impacts. DPEIR 13-8. Indeed, there is scientific consensus that neonicotinoid pesticides harm bees, and this is why EPA mandates that all neonicotinoid pesticides state "Do not apply this product while bees are foraging. Do not apply this product until flowering is complete and all petals have fallen . . . ."[12] Likewise, as discussed above, EPA recognizes that the Program's chemicals are likely to harm bees. Because the cumulative impacts analysis focuses solely on colony collapse disorder, the larger picture of pollinator impacts is ignored. 26

Second, the DPEIR improperly attributes urbanization and urban limitations on beekeeping as a significant impact on pollinators in the Program area. While urban growth and regulations limiting beekeeping can also impact bees, the regulations and land use patterns in MSMVCD's service area do not appear to be a significant limitation on beekeeping. In Marin County, only Mill Valley has adopted a complete ban on beekeeping; it is allowed outright in unincorporated areas and some municipalities, though some require permits.[13] Sonoma County likewise permits beekeeping.[14] While Santa Rosa explicitly bans *commercial* beekeeping, no 27

[12] http://www2.epa.gov/pollinator-protection/new-labeling-neonicotinoid-pesticides

[13] *See, e.g.*, Marin County Department of Agriculture, Weights and Measures, Frequently Asked Questions, General Information, "*I want to keep bees, what do I need to do?*" available at http://www.marincounty.org/depts/ag/faqs (last visited September 29, 2015).

[14] Sonoma County Code https://www.municode.com/library/ca/sonoma_county/codes/code_of_ordinances?searchRequest={%22searchText%22:%22beekeeping%22,%22pageNum%22:1,%22resultsPerPage%22:25,%2

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municipality in Sonoma County explicitly prevents backyard beekeeping. Indeed, Petaluma, Cloverdale, Rohnert Park, and Windsor allow beekeeping, according to their websites or municipal codes. But pesticide applications in the MSMVCD can occur in much more diverse areas that those urban islands where beekeeping is regulated. By overstating the impact of urban beekeeping regulations, the DPEIR understates the Program's cumulative impacts. 27

Third, the DPEIR completely ignores the significant role of wild pollinators, such as native bumblebees, butterflies and moths. Like its analysis of direct impacts, the DPEIR conflates domesticated honeybees with *all* pollinators. DPEIR 13-8. But, as discussed above, pollination is performed by a variety of other insects, including wild native bees, butterflies, moths, and flies, as well as hummingbirds and bats. Unexamined impacts on these non-honeybee pollinators include the loss of non-target insects caused by use of spinosad and pyrethroid type insecticides (including but not limited to synthetic pyrethroids, permethrin, and etofenprox). This loss of non-target insects can reduce populations of insect pollinators and also diminish an important food supply for bats. Because the DPEIR declines to address food-chain impacts, it does not analyze whether localized loss of insect populations will harm insectivores, including pollinating bats. 28

Similarly, the DPEIR's cumulative water quality analysis is sorely lacking. DPEIR 13-16. As discussed above, the DPEIR fails to show that the chemical control and vegetation management components will not enter impaired waterways. Its statement that MSMVCD's "use of these 'impairment chemicals' is contributing in less-than-significant amounts" is wholly unsupported by the facts and analysis CEQA requires. DPEIR 13-16. CEQA mandates that the EIR contain information sufficient to allow the public to trace the agency's analytical path from evidence to conclusion. *Laurel Heights Improvement Association v. Regents of University of California* (1988) 47 Cal.3d 376, 404. Moreover, under CEQA, even a "de minimis contribution" to an existing cumulative impact may be significant. *Communities for a Better Environment v. California Resources Agency* (2002) 103 Cal.App.4th 98, 117-121; *see also* Pub.Res.Code § 21083(b)(2) ("individually limited" impacts may still be "cumulatively considerable"); Guidelines § 15065(a)(3) (same). 29

Without the required adequate groundwork, the DPEIR cannot accurately determine the Program's potential cumulative impacts, and therefore it cannot mitigate them. As discussed above, the DPEIR's cumulative impacts discussion is fatally flawed in numerous respects. This must be remedied in a recirculated DPEIR. Guidelines § 15088.5. 30

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SCOPE OF ANALYSIS FOR FUTURE SITE-SPECIFIC PROGRAM ACTIVITIES

"A program EIR is an EIR which may be prepared on a series of actions that can be characterized as one large project and are related" to each other. Guidelines § 15168(a). However, "[s]ubsequent activities in the program must be examined in the light of the program EIR to determine whether an additional environmental document must be prepared." Guidelines § 15162(c). "Certainly, a program EIR will better fulfill its purpose of reducing the need for subsequent environmental review the more comprehensive and specific the analysis it provides." *Center for Biological Diversity v. Department of Fish and Wildlife* (2015) 234 Cal.App.4th 214, 234. "When an activity is within the scope of the program reviewed in the program EIR but the environmental impacts of the activity are not evaluated, *a further tiered CEQA analysis must be completed* before the activity may be approved." 1 Kostka & Zischke, Practice Under the California Environmental Quality Act (Cont.Ed.Bar 2d ed. 2014) § 10.16, p. 10–23 ("Kostka"), emphasis added, *citing Center for Sierra Nevada Conservation v. County of El Dorado* (2012) 202 Cal.App.4th 1156.

In order to determine whether future site-specific program activities fall within the scope of the program EIR, "the agency should evaluate the site and the activity to determine whether the environmental effects were covered in the program EIR and document its findings by a checklist or other means." Kostka, § 10.16, p. 10–22. Here, however, MSMVCD glosses over this important program EIR requirement, while conceding that it does not have site-specific or project-specific information. DPEIR 1-22 to 1-27. The DPEIR admits that its analysis is limited to "the activities and materials [that] can be identified at present," and that CEQA requires additional analysis for activities not adequately covered in the program EIR. DPEIR 1-22, 1-23. Yet the DPEIR concludes that "[a]ll pesticides in current use have been evaluated in the PEIR" and that "[f]uture formulations are likely to include ingredients already evaluated," presumptively dismissing the need for future CEQA evaluation despite the lack of site-specific information or knowledge of how future formulations of pesticides and herbicides would react when applied together. DPEIR 1-23. The DPEIR's attempt to preemptively dismiss any need for CEQA review of future Program activities subverts the purpose of CEQA, and the streamlining goals of tiering EIRs. Pub.Res.Code §§ 21002, 21100; Guidelines §§ 15121, 15151, 15165, 15168.

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DPEIR CITATIONS AND REFERENCES

The DPEIR relies on numerous references that do not stand up to scrutiny. DPEIR 17-1 to 17-15. First, the DPEIR repeatedly references the Bay Delta Conservation Plan ("BDCP") in its analysis of biological impacts. DPEIR 4-47 to 4-49, 5-28, 17-2. However, reliance on that document is misplaced. The DPEIR relies on a draft document that is already out of date, and indeed, was out of date at the time the DPEIR was published. *Id.* Despite the DPEIR's claim

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that the BDCP is "being developed as a 50-year habitat conservation plan," that has not been the case since April of 2015, four months prior to publication of the DPEIR.[15] Reliance on the outdated draft BDCP to identify the Project's impacts and alternatives, and shape its mitigation measures, is improper and must be remedied. *County of Amador v. El Dorado County Water Agency* ("*County of Amador*") (1999) 76 Cal.App.4th 931, 949 (reliance on growth projections from a *draft* general plan violates CEQA). 32

The DPEIR also cites unreliable sources, such as Wikipedia – the "free [online] encyclopedia that *anyone can edit*."[16] CEQA intends for the DPEIR to be an informational document, and reliance on an open-source website does not "provide decision makers with information which enables them to make a decision which *intelligently* takes account of environmental consequences." Guidelines §§ 15151 (quote, emphasis added), 15121. The resources relied upon in making determinations in the DPEIR must be from accurate and reputable sources. 33

The DPEIR's reference list also includes numerous website links that are either broken or direct the reader to an incorrect page. *E.g.* DPEIR 17-1 (Bay Area Air Quality Management District 2009), 17-2 (Bay Delta Conservation Plan 2014), 17-4 (California Environmental Data Exchange Network 2013), 17-6 (Corte Madera Planning Department 2009), 17-7 (Healdsburg Planning Department 2011), 17-9 (National Oceanic and Atmospheric Administration 2008), 17-10 (Northern Sonoma County Air Pollution Control District 2012, Northern Sonoma County Air Pollution Control District 2014, Ross Planning Department 2011, Ross Planning Department 2007, San Anselmo Planning Department 2011, San Anselmo Planning Department 1989), 17-11 (Solano County 2008, Solano County Water Agency 2012, Sonoma County 2008, Sonoma County 2009, Sonoma County 2014, Sonoma County undated), 17-12 (Tiburon Planning Division 2005, Underwriters Laboratories LLC 2012, United States Environmental Protection Agency 1991b), 17-13 (United States Environmental Protection Agency 2009c), 17-14 (United States Environmental Protection Agency 2014c, World Health Organization 1989). These errors must be corrected. 34

CONCLUSION

For the reasons outlined above, the DPEIR must be significantly revised to include a

[15] Bay Delta Conservation Plan, DWR Announces Modified Preferred Alternative, available at: http://baydeltaconservationplan.com/2015news/15-04-30/DWR_Announces_Modified_Preferred_Alternative.aspx

[16] Wikipedia Slogan, available at: www.wikipedia.com/wiki/wikipedia

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proper scope of analysis, project description, range of alternatives, and impact analysis.

Respectfully submitted

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Response 1

Figure 2-1 does precisely show the boundaries of the entire Program Area on a detailed base map. CEQA requires that the project area include the area where all potential impacts could occur. The Draft EIR states that any of the adjacent jurisdictions to the Service Area counties could be affected by the Proposed Program if the District was asked by the adjacent county vector control agency or vector control district to provide assistance in their county, and the Program Area includes the counties that are adjacent to the immediate Service Area counties of Marin and Sonoma most likely to request assistance. These are shown on Figure 2-1, along with Marin and Sonoma counties. Mosquitoes may travel long distances, and their movement is not limited by jurisdictional boundaries. For example, the salt marsh mosquito (species *Aedes dorsalis*) is an aggressive biter that may travel 20 miles for a blood meal. Also, because the District has an airboat, adjacent districts could ask the District to provide assistance to areas most accessible by airboat. Thus, the analysis conservatively assumes that an entire adjacent county could be affected, but most impacts would be concentrated in Marin and Sonoma counties. Of greatest concern would be a vector population originating in an adjacent county where Service Area residents and recreationists could be affected.

Response 2

The alternatives terminology referenced in this comment is explained further and clarified herein. Traditionally, CEQA documents have the resource chapters examine the entire program/project for environmental impacts based on applicable environmental topics or concerns. Then, alternatives to the proposed program/project that would reduce or avoid any significant impacts and the no program/no project alternative are discussed in a separate chapter that may be supplemented by an appendix on the alternatives selection process explaining how the proposed program/project was developed. This traditional format is followed in the District's document. Chapters 3 through 12 discuss the environmental impacts associated with the Proposed Program in its entirety, while alternative programs are described in Chapter 15. The explanation below clarifies these two uses of the word "alternative", "Program alternative" and "alternative Programs".

The proposed project is a continuation of the District's ongoing Program for mosquito and vector management. The District currently employs a Program consisting of six alternatives, which the Draft PEIR characterizes as "tools" or "components" of the overall Program, that are implemented as necessary and appropriate based on the Program needs and objectives. These Program alternatives are groups of related or similar activities by type. The District has approximately 20,000 sources that it monitors on a regular basis for mosquito abundance, species, and life cycle. It also responds to complaints and requests for service at other sites as well. At each site where actual treatment is needed, the District has to determine quickly which of the alternative components within its Program is best suited to dealing with the mosquito or other vector problem. As described in the Draft PEIR, the District's management practices emphasize the fundamentals of integrated pest management (IPM), specifically integrated vector management (IVM), which involves the use of multiple tools, including source reduction (physical control), habitat modification (vegetation management), and biological control using mosquitofish, when appropriate before using pesticides. So on a site-specific basis, the District selects from its nonchemical control alternatives first, then from its chemical control alternative, if necessary. Site conditions, including

the potential for special-status species to be present and proximity to human activities, affect the alternative(s) selected.

The PEIR's use of the term "alternatives" in the context of the project description is described in Chapter 2, Program Description, as alternative components of the proposed Integrated (Mosquito and) Vector Management Program (IVM Program or Program). The role of these alternative components in the Program is described in Chapter 2, Section 2.3, page 2-5, which explains:

> "The District has, for at least the past 2 decades, taken an integrated systems approach to mosquito and vector control, utilizing a suite of tools that consists of public education, surveillance, source reduction (e.g., physical control, vegetation management, water management), biological, and chemical controls. These Program "tools" or components are described in the subsequent subsection as "Program alternatives" for the CEQA process (except for public education, which is exempt from CEQA)."

Section 2.3, page 2-6, further explains:

> "The District's Program consists of the following alternatives, which are general types of coordinated and component activities, as described below: surveillance, physical control, vegetation management, biological control, chemical control, and nonchemical control/trapping. The Proposed Program is a combination of these alternatives with the potential for all of these alternatives to be used in their entirety along with public education."

Thus, the contention that the PEIR's use of "alternatives" in the context of the project description and environmental analysis suggests the program components "are separate from one another when they would be combined into one comprehensive alternative" is not correct. These Program components are distinguished as alternatives in separate sections of each impact chapter to ensure that they are fully evaluated on a comparable basis, in similar depth, and so that impacts are explained clearly for each resource or environmental topic. This approach was selected because the various components of the Program (e.g., Vegetation Management, Water Management, etc.) differ in their objectives, method, and potential impacts. Each resource chapter considers the environmental impacts of the same Program alternatives or "components." This way the impacts of each Program component can be compared against those of the other components and in total to promote the District's informed decision regarding which "alternative" or components to use in a particular situation. While the District could have referred to its suite of proposed tools as "components" rather than "alternatives," that choice would not have changed the analysis nor would it have affected the District's separate evaluation of CEQA mandated alternatives to the project that would avoid or substantially lessen the significant environmental impacts of the project, which was provided in Section 15.

CEQA alternatives to the Proposed Program are thoroughly addressed in Chapter 15, Alternatives, which describes CEQA requirements, the process used for screening alternatives (Section 15.1), alternatives that were considered but rejected from further consideration (Section 15.2), impacts of the No Program Alternative (Section 15.3), and alternatives that would avoid or substantially lessen the significant environmental effects of the Program (Section 15.4). Two such alternative Programs were identified: the Reduced Chemical Control Alternative Program (Section 15.4.1) and the No Chemical Control Program (Section 15.4.2). The impacts of the Proposed Program and these "alternative programs" were compared (Section 15.5), and the environmentally superior alternative was identified (Section 15.6). Thus, all of the CEQA requirements for "alternatives" were addressed.

Response 3

The comments that the use of BMPs makes the project description inaccurate and unstable and that these actions are actually mitigation measures that are unenforceable and vague are incorrect. Further information on the origin of these BMPs and their use by the District is provided below.

The District has been engaged in vector control since 1915. The current Program is being evaluated as the Proposed Program along with additional activities or chemical treatments that the District would like to have available or is considering for use in the future. The BMPs have evolved over many years of practice and coordination with wildlife refuge managers, water district staff, CDFW biologists, and USACE engineers on previous agency permits including measures to minimize disruption to special-status species and their habitats. They help to meet overall Program objectives. In some cases, not all, the BMPs are less specific than similar mitigation measures would be in order to provide for flexibility in dealing with a variety of sites and different chemical treatments as a form of adaptive management to deal with changing physical and biological conditions. In other cases, they are very specific; i.e., do not allow for deviation from product application label requirements. Pesticide label restrictions cover application rates and methods, storage, transportation, mixing, and container disposal that have become part of the District's ongoing practices.

The District has developed and adopted these BMPs, is using them in the current Program, and will consider modifications as requested by USACE, CDFW or other resource agencies. In short, the BMPs are an integral part of the District's current Program, are to be continued into the future, and are properly treated as part of the proposed Program being evaluated in the PEIR. Ignoring the effect of these ongoing practices would mischaracterize the Program being evaluated, resulting in misleading and inaccurate impact analyses.

It is possible District BMPs could be modified over time to meet resource agency requirements or site conditions. For example, the process for renewing the District's 5-year regional permit with the USACE and its Supplemental Use Permit for vector control on USFWS lands may identify more specific requirements. The USACE permit application is submitted to CDPH, who then sends it to the resource agencies including CDFW. The District will continue to coordinate with CDFW on possible future refinements to BMPs to address specific habitat or site conditions, including provisions for vegetation and sediment removal in drainage channels and ongoing responsibilities for maintenance of the affected areas.

By contrast, mitigation measures are typically new measures added to a project to reduce impacts. For example, in Mitigated Negative Declarations, mitigation measures are new requirements added to the Project to avoid, minimize, eliminate, rectify/compensate for, or otherwise reduce significant impacts from the project under evaluation. They are then incorporated into the project description to indicate the project proponent has committed to implementing these measures. There are also numerous examples of EIRs where project features are similar to mitigation measures and are, therefore, considered in conducting the environmental impact analysis. Examples include both the programmatic and project-specific environmental impact documents for restoration of the San Joaquin River prepared by the Bureau of Reclamation (e.g., San Joaquin River Restoration Program) and the Department of Water Resources and State Lands Commission (combined CEQA/NEPA documents).

The PEIR fully evaluates all potential impacts of the Program, and the commenter has not explained how the inclusion of the BMPs resulted in the PEIR failing to identify or accurately evaluate any particular potential Program impacts. In short, the BMPs do not result in avoiding analysis of a potential impact.

Response 4

Treating the educational aspects of the Program as exempt from CEQA is not an example of segmenting the project. Rather, as explained in Chapter 2, Section 2.4, pages 2-41 to 2-43, educational programs such as those conducted by the District are exempt from CEQA, and the subsequent sections try to explain the educational activities that are exempt, as well as where CEQA review is needed. Actions that are categorically exempt from CEQA because they have been determined not to have a significant effect on the environment are listed in Article 19, Categorical Exemptions, of the CEQA Guidelines. These include educational or training programs that involve no physical alteration in the area affected (CEQA

Guidelines § 15322). The types of activities that are used by the District that meet this definition are described on page 2-43 as follows:

> "An excellent mosquito/vector prevention program includes good public education and outreach as key components. The District's education program teaches the public how to recognize, prevent, and suppress mosquito/vector breeding on their property. This part of the project is accomplished through the distribution of brochures, fact sheets, newsletters, participation in local events and fairs, presentations to community organizations, newspaper and radio advertising, public service announcements, social media postings, District website postings, and contact with District staff in response to service requests. Such activities involve negligible use of office supplies, and any vehicle trips are covered by the estimated equipment usage under surveillance and other nonchemical control activities. Public education also includes a school program that teaches future adults to be responsible by preventing and/or eliminating vector breeding sources and educates their parents or guardians about District services and how they can reduce vector-human interaction. Where activities designed to prevent or eliminate vector breeding sources are consistent with the activities performed by the District under the Program alternatives, they may be covered sufficiently for environmental impact in this PEIR." (page 2-43)

The literature, local events, and training through public presentations to schools and community groups is described above and are covered under the education exemption. The potential secondary effects of its education process are also either exempt from CEQA or adequately described in the PEIR. One example is a homeowner or property owner making a request for service at an existing facility, and the District then advising the property owner to modify their landscaping to avoid ponding/improve drainage, reduce stagnation of water in ornamental ponds, or modify their structure to block access points by rodents. The District's use of equipment is covered under the Surveillance Alternative or under Physical Control Alternative. Maintenance of existing landscaping and minor alteration of existing public or private structures, facilities, mechanical equipment, or topographical features, involving negligible or no expansion of use is exempt from CEQA under CEQA Guidelines Section 15301, Existing Facilities. If the property is abandoned, and there is an abandoned swimming pool or ornamental pond, the District will abate the mosquito-breeding problem most likely under the Biological Control Alternative. For potential major alterations of the physical environment at a site, the Draft PEIR states the following:

> "Educational activities also include making recommendations on specific property development and land and water management practices or proposals, in response to ongoing or proposed developments or management practices that may create sources of mosquitoes/vectors. To ensure that the District does not indirectly encourage environmental impacts without CEQA review, the District informs landowners and others who might modify the physical environment in response to educational programs that they have specific environmental obligations, including compliance with CEQA and permit requirements. The District is not a permitting agency and it is not responsible for implementing or approving the control recommendations on specific property development; therefore, property owners or developers are required to prepare and submit their own documents for projects, which may require CEQA review." (page 2-43)

In summary, parts of public education are covered by different exemptions contained in the CEQA Guidelines. The PEIR text has been modified on page 2-41 to clarify the applicable exemptions (shown below).

> Public education is a key component of the District's IVMP that is used to encourage and assist reduction and prevention of vector habitats on private and public property. <u>This component includes educational or training programs that involve no physical alteration in the area affected.</u> While this component is a critical element of the District's Program,

public education activities are categorically exempt from CEQA review (CEQA Guidelines Section 15322) based on a finding by the State Secretary of Resources that these activities do not have a significant effect on the environment. ~~Therefore, these educational activities will not be further reviewed in this document.~~ Under Article 19, Categorical Exemptions, maintenance of existing landscaping and minor alteration of existing public or private structures, facilities, mechanical equipment, or topographical features, involving negligible or no expansion of use is covered in Section 15301, Existing Facilities. A discussion of exempt and nonexempt educational activities is provided in the following paragraphs.

There was no intent to segment the Program into smaller pieces to avoid CEQA review, and the commenter has not identified any potentially significant impacts that the PEIR failed to consider as a result of the determination not to evaluate the public education component of its Program.

Response 5

Please refer to Response 3 regarding the use of BMPs and Responses 6 through 30 regarding the adequacy of the impact analysis. The commenter has not provided substantial evidence documenting that additional significant impacts would occur beyond the air quality impact associated with the Chemical Control Alternative, and the two alternatives addressed in Chapter 15 would both reduce this impact to less than significant. No significant impacts on biological resources and water quality would occur; thus, no additional alternatives are required. There is a difference in opinion on what a significant impact is and what is not in this PEIR between the commenter and the PEIR preparers. See Response 15 below on the use of best professional judgment by PEIR preparers with the appropriate technical qualifications to evaluate the impacts of ecological concern.

Response 6

There have been numerous reports on the possible toxicity of some pesticides to insects, including some beneficial insects such as pollinators. Of particular interest are use of spinosad and pyrethroid-type insecticides (including but not limited to synthetic pyrethroids, permethrin, resmethrin, and etofenprox). As with all pesticides (where the purpose is to reduce populations of insects), the toxicity varies by species and chemical. Each chemical registered is supported by a large database directly addressing the direct and sometimes indirect toxicity. These data are available in the USEPA databases that include all available physiochemical characteristics and toxicology data for a spectrum of terrestrial and aquatic vertebrate and invertebrate species. In a typical chemical (pesticide) toxicity database, the results of tests on numerous species provide a comparison of relative sensitivity to each chemical listed. The information in the database includes the results of tests on several potential routes of exposure and both acute and sub-lethal effects on many nontarget species, and it was used to consider the possible unwanted effects of a vector control product and what restrictions, if any, might be considered for use in the District's BMPs and in preparing the Draft PEIR.

The District's objective is to reduce or minimize the possibility of unwanted nontarget effects in the local environment while addressing the need for vector control. These considerations and how unwanted effects can be eliminated or reduced are embodied in the Program objectives and in each of the applicable BMPs and guide all pesticide applications. By restricting chemical applications to times when nontarget insects are not active and using care to treat only vector larvae and adults in locations where they are concentrated (i.e., population is high enough to warrant control), impacts to other species are eliminated or substantially reduced.

In situations where inadvertent exposure to other, beneficial insects might occur, the impact to a few individuals will not adversely impact the population(s), which can recover quickly to original population levels (Emlen et al. 2003; Andrewartha 1972).

Furthermore, the vegetation management option of using glyphosate has been shown to be one of the safest herbicide products for over 40 years. Claims that glyphosate impacts bees are based on a report by Herbert et al. 2014 that conducted simulated "field tests" to evaluate the effects of glyphosate on honeybee behaviors. These authors designed their study to determine what impact exposures to glyphosate might have on honeybee foraging and hive identification behaviors. Although the hypothesis of these authors predicted that honeybee behaviors would be adversely impacted after exposure to the herbicide glyphosate, the behaviors they studied were not adversely affected by the exposures and their conclusion was "no effect on foraging related behavior was found in these behavioral studies". The PEIR considered the impact of glyphosate on bees in Chapter 6, Ecological Health, under the Vegetation Management Alternative, Section 6.2.5.1.1 (page 6-20).

There are many credible theories as to the causes of the reduction in bee numbers (where they occur), including the effect of drought on the flora sources, the rise of parasites, fungi, and other classic bee diseases, and it is likely that these sources of stress are the most important adverse effects on bee colonies.

Response 7

First, the commenter mischaracterizes assumptions affecting conclusions under CEQA regarding pollinators. The comment that the DPEIR "incorrectly assumes that BMPs it proposes will prevent *any* significant impacts to pollinators" is misleading. In particular the District uses the following BMP H12 for pesticide applications that is contained in Table 2-6 in Section 2.9:

> "Do not apply pesticides that could affect insect pollinators in liquid or spray/fog forms over large areas (more than 0.25 acres) during the day when honeybees are present and active or when other pollinators are active. Preferred applications of these specific pesticides are to occur in areas with little or no honeybee or pollinator activity or after dark. These treatments may be applied over smaller areas (with hand held equipment), but the technician will first inspect the area for the presence of bees and other pollinators. If pollinators are present in substantial numbers, the treatment will be made at an alternative time when these pollinators are inactive or absent." (page 2-69)

The District BMPs are in place now, and have been used effectively, because there is no evidence to show harm to pollinators and the plants they affect from District activities in the District's Service Area, which contains important agricultural resources such as vineyards that are dependent on pollinators. For example, the District routinely treats several tidal, brackish, and fresh water mosquito habitats along the Petaluma River corridor, which attract birds but also create abundant mosquito populations. Nearby agricultural grazing lands for dairy cattle and vineyards thrive and show no discernible effects of insufficient pollination. The District does not receive complaints from these property owners. Furthermore, the CEQA conclusions of less-than-significant impacts are based not only on the BMPs but on application methods and the concentration and type of chemical materials used. All of these factors, and including the physical context in which the applications occur (that subject the treatments to sunlight, air, and soil conditions that minimize persistence and facilitate breakdown) support the Draft PEIR conclusions that the effects are not substantial or adverse enough to be characterized as significant, not that there is a conclusion of zero or no impact. There could be a loss of some individual insects on occasion during an application, but the loss would not be substantial for reasons cited below and in Response 6 above.

Adverse impacts to non-bee pollinators (including nocturnal moths) or insect predator populations have not been reported (by adjacent landowners or wildlife refuge managers) as a result of focused applications of District pesticides. (Nocturnal moths pollinate nocturnal flowers with pale or white flowers heavy with fragrance and copious dilute nectar.) In fact, pollinator populations fluctuate over time and are affected by many different contributing factors. It is not possible to definitively link use of vector control products by the District (at levels established by the USEPA and according to additional District BMPs) to a long-term decline or one that would adversely impact the pollinator or predator population of interest. It is well known

in population biology that every population can adequately respond and recover to a loss of large percentages of individuals based on their intrinsic reproductive vigor. Populations with very short reproductive gestation periods (most insects and some small mammals) will recover much faster than populations with long reproductive cycles (large mammals and some birds) (Andrewartha 1972). In fact, there are many current theories about how many individuals in a population can be lost before the likelihood of significant impact or extinction may occur, but some experts suggest the total population of animals (and insects) with very short reproductive cycles (gestation times) can lose as much as 30 percent of the population and still experience complete recovery to pre-stress numbers (Emlen et al. 2003). In the case of insect predators, even a fraction of this number would suffice to replenish the population to pre-exposure numbers. Furthermore, the overwhelming majority of the District's adulticide applications are site specific applications using hand held and/or backpack equipment. These applications are performed as necessary to reduce substantial populations of adult mosquitoes in the interest of public health. Annually, a considerable portion of the District's adult mosquito applications are performed in conjunction with contained, anthropogenic sources such as septic tanks and water and/or sewage leaks beneath buildings. When an adult mosquito population(s) is reduced, adulticide applications are no longer required at a given site, unless there is an additional occurrence at another point in time. With the exception of a small number of especially problematic sites (e.g. sewage treatment plants) adult mosquito control applications are performed infrequently at a given site. Overall, on an annual basis and considering the District's service area, adult mosquito control applications are small scale and relatively infrequent.

Response 8

Visual inspection of the area to be treated prior to treatment is a prudent and practical approach to evaluate the possible presence of potential nontarget species of concern including pollinators. The practice of visual inspection of a site *prior to* application of the pesticide indicates the care given by the District to reduce or minimize potential impacts to readily identifiable nontarget species such as bees and butterflies. Visual inspection is done to avoid applying pesticides when pollinators are observed flying.

The concern stated in the comment that visual inspection will not prevent "post application harms" and "pesticide residues will remain in toxic amounts" is misleading and is really a question about persistence of the active ingredient in pesticides used by the District. The persistence of pesticide products is dependent on the physical/chemical conditions of the soils and vegetation treated. The persistence of the chemicals used by the District for vector control after an application to soils or sediment is reduced markedly by the characteristics of the surface soils and/or vegetation.

The persistence of all chemicals registered by the USEPA for use in vector control is documented and included in the guidance and label instructions, both of which are summarized in the chemical MSDS (now SDS) documents. For instance, the persistence of glyphosate in soil and sediment has been studied since its development in the early 1970s. The characteristics of glyphosate have been studied and validated over decades. Every organic chemical has a physical/chemical degradation characteristic termed "half-life" (a metric used to describe the elapsed time for a chemical to reach ½ of its initial concentration). Each organic chemical, whether toxic or not, decays in both activity and toxicity over time. For some chemicals, the half-life can be hours, days, or weeks and few chemicals used as pesticides have half-lives normally greater than a week due to degradation by environmental conditions. When pesticides get into soil, or water, or are taken up by plants and animals, the half-life characteristics are altered. The environmental fate of pesticides depends on the physical and chemical properties of the pesticide, particularly the pH of the medium, modifying how likely it is to travel through soil (soil mobility), how well it dissolves in water (water solubility), and how likely it is to become airborne (volatility) (USEPA 1993).

Once a pesticide has been released into the environment, it is broken down by exposure to sunlight, (photolysis), exposure to water (hydrolysis), exposure to other chemicals (oxidation and reduction), microbial activity (bacteria, fungi, and other microorganisms), and other plants or animals (metabolism). Pesticide labels set out safety and use guidelines that usually focus on three aspects: rates of application (single and cumulative) for registered crops and pests, timing of application, and restrictions on areas of application (including required buffer zones).

The environmental fate of pesticides used by the District for vector control is influenced by their chemical properties and by the environmental conditions in which they are applied. The Draft PEIR's Appendix B, Ecological and Human Health Assessment Report, provides a detailed description of the fate and transport in air, water, and soil for each of the active ingredients applied by the District. For example, a summary of the potential uses of glyphosate products by the District is included in Appendix B Table 6-1 and the narrative in Section 4.6.2 of Appendix B. Many second-and third-generation insecticides are formulated to act quickly and then dissipate quickly in the environment, often through photolysis or microbial breakdown. Others bind to soils and sediments where they are degraded abiotically or by soil organisms. These effects, the potential for mobilization after pesticide application and the methods used to minimize exposures to nontarget ecological receptors, are considered in the discussion of the Vegetation Management and Chemical Control Alternatives (see Sections 9.2.5 and 9.2.7 of the PEIR).

There are numerous pesticide products that include inert and/or chemically different additives to enhance the spray characteristics, adhesion properties, and efficacy. Many of those products have been specially tested for toxicity and registered with the USEPA for specific vector control purposes (National Park Service 2016). Although some of these mixture products have been associated with increased toxicity, numerous studies have demonstrated that the increase in toxicity may be due to a surfactant additive. In most instances, these special formulations of pesticide products are intended to reduce the potential for adverse effects or to specifically be used for aquatic environments, e.g. a glyphosate product, Accord, is a formulation of glyphosate which has been shown to be safer to aquatic wildlife than some of the other formulations of glyphosate (Brodman et al. 2010).

All chemicals can cause adverse effects or even become be toxic at levels exceeding individual species "tolerance" levels. However, the sensitivity and tolerance levels are determined by the USEPA and other regulatory agencies using laboratory tests with numerous species of concern that are estimated to be potentially exposed to an application. The results of these tests on each chemical are published in numerous publically available USEPA documents summarizing the testing results with metrics such as the LD_{50}, LC_{50} and maximum estimated tolerance levels. For the pesticides used by the District for vector control, these metrics are indicated in detail in Appendix B of the PEIR, with information on a current species of interest (honeybee). In several studies, one, for instance, (Frasier and Jenkins 1993) indicate that both technical and formulated glyphosate are practically nontoxic to honeybees with a contact LD_{50} value greater than 100ug/bee (applied directly to the thorax with a saturated Q-tip), which is considerably greater exposure than likely in the environment where applications could occur.

The half-life and other physiochemical characteristics of the chemicals used by the District for vector control are listed in Table 6-1 of the PEIR Appendix B.

Response 9

Glyphosate is an herbicide that is relatively stable to chemical and photo decomposition. The primary pathway of glyphosate degradation is soil microbial action, which yields the minimally toxic breakdown product AMPA and glyoxylic acid. Both products are further degraded to carbon dioxide. Glyphosate adsorbs tightly to soil so that its residues are relatively immobile in soil (USEPA 1993). This characteristic results in the chemical (when it is in the soil) being less available as a route of exposure and would require direct ingestion of the soil or sediment, which is not likely by insect pollinators who focus on flowers.

Although the term sub-lethal effect is often misused outside the scientific community, it defines the effects of a stressor (pesticide in this case) that is less than mortality. It includes evaluation of the potential effects on physiological and behavioral systems that may occur over time or result in a deficit of a physiological function. Although important in the determination of the potential adverse impacts of the pesticide, it is the "endpoint" most susceptible to confounding, outside, environmental factors. Adverse effects that are categorized as sub-lethal are also often confused with the concept of chronic effects, which include low level effects that are continued over long periods of time and usually associated with constant exposures to a stressor. Because this condition is not typical of District vector control applications of chemical (generally single localized applications) it is not relevant to the evaluation of District use of pesticides or herbicides.

However, one of the sub-lethal effects considered by the scientific community is evaluation of behavioral responses to chemical exposures. This was the focus of the work by Herbert et al. discussed in detail in Response 6. The conclusion of this study, which was designed to evaluate the very subtle behavioral responses to a pesticide exposure, was "no effect on foraging related behavior was found in these behavioral studies." Regardless of their negative behavioral results, the authors suggested that the bees may have been able to carry pesticide to the hive (which was not and is not a measurable endpoint) as a reason for the reduction in the number of bees (which was also not observed in their studies). This study provides no support to the authors' hypothesis of behavioral deficit after exposure to the pesticide in the study.

Claims suggesting pesticide applications have clear sub-lethal adverse effects on bees and bee colonies are not supported by the preponderance of relevant scientific publications. Most of the reports of reduced bee numbers and colony collapses do not include consideration of the numerous confounding factors that impact the bee colonies, diminishing their evidentiary value. The effects of drought, disease, parasites, viruses, and predation all play a role when impacts to bees are reported.

In conclusion, the District's applications of pesticides for vector control are done in strict compliance with USEPA, manufacturer, and BMP guidance, which are designed to minimize exposure to pollinators. District application methods and chemical characteristics of the products used and proposed for use make the potential for long-term (chronic) exposure to insect pollinators unlikely. Finally, the comment presents no substantial evidence that application under the Program will result in substantial adverse sublethal effects to pollinating insects, and the available scientific literature also does not support such claims.

Response 10

As discussed in Responses 6 through 9, the Draft EIR correctly analyzed the impacts associated with the Proposed Program, and additional information is provided herein to support the original conclusions as well as consideration of information provided by the commenter. The information above provides clarification of material contained in the PEIR and addresses specific questions raised in public comments for this Final PEIR. None of the comments identified substantial evidence of a new significant impact that was not considered in the Draft PEIR, and no Draft PEIR impacts need to be changed from less-than-significant to significant; thus a re-circulated Draft PEIR is not required. Also see Response 15 below on the technical qualifications of the principal toxicologist who worked on the Draft PEIR and prepared responses to many of the questions raised herein on the chemical treatments. The technical qualifications of all of the preparers of the District's PEIR are summarized in Chapter 16, Preparers.

Response 11

Some of the chemicals used for vector control include the pyrethroid insecticides such as permethrin, resmethrin, and etofenprox that are used as adulticides by the District. While these chemicals are not very toxic to terrestrial species of mammals and birds (they are below the EPA LOC for most uses) they can be toxic to aquatic species at high concentrations. The toxicity of these pesticides is species specific, and the thresholds provided by the USEPA guidance indicate that it should not be introduced to aquatic systems. As with all chemicals, the exposure (dose) is the primary factor resulting in potential toxicity, and care is taken by the District to reduce or minimize the possible introduction into water bodies. As stated on page 9-35:

> "The use of adulticides to control mosquitoes is the method of control in the bottom tier of the District's IVM program. Adulticides are only applied when other tools are not available or applicable and when specific criteria are met, including species composition, population density, proximity to human populations, and/or human disease risk. The active ingredients currently in use have been deliberately selected for lack of persistence and minimal effects on nontarget organisms when applied in strict conformance to label instructions for ULV mosquito control. Adulticides are applied following District BMPs, using ground application equipment or applied in the future using rotary and/or fixed wing aircraft, and used in strict conformance with label requirements and the District's PAP."

Further discussion is provided on page 9-37:

> "Several studies have shown that pyrethrins applied using ULV techniques do not accumulate in water or sediment following repeated applications. These studies also determined that no toxicity is associated when exposure is limited to the amounts used when following ULV protocols for mosquito control (Lawler et al. 2008; Amweg et al. 2006). Pyrethrins would have a less-than-significant impact on surface water or groundwater, including their limited use near septic systems, when applied following District BMPs and using ULV techniques, and when used in accordance with label requirements and the District's PAP."

The characteristics of these chemicals reduce the likelihood of exposure to nontarget species because they bind to soil, making them less likely to be available. Because they are known to be toxic to some of the aquatic species, applications are conducted using ULV techniques and with strict adherence to the product labels as determined by the USEPA guidance (USEPA 2009). Special precautions and BMPs are used to ensure that they are not introduced into the aquatic environment in amounts that would impact nontarget species, including benthic invertebrates. The statement on page 4-97 that product could encounter water means it is possible that a small amount could reach the water surface, not that it is actually applied to the water. Furthermore, adulticides are meant to encounter the adult mosquito in the air or resting on vegetation. The verbal context in which the few words were extracted and misrepresented by the commenter is provided below:

> "For example, the maximum application rate of an adulticide that could be used is 0.87 ounce/acre, although maximum application rates are generally not required. The concentration of the active ingredient is 5 percent or less of this volume. This translates into a water concentration of 1.04 µg/L if the water is one foot deep or 4.14 µg/L if the water is three inches deep. This assumes all of the product contacts the water. Aerial applications are made over vegetated areas preferred by adult mosquitoes, so the amount of product encountering the water is generally a fraction of this." (page 4-97)

This USEPA guidance is one of the factors used to develop the BMPs for pesticide applications, including the requirement to maintain adequate buffers between the application area and the edge of the water body for some materials. By following these USEPA recommendations, the likelihood that the pesticide will result in adverse aquatic impacts is very low.

Where it becomes necessary to treat storm drains with pyrethroids to eradicate localized infestations, care is taken to document the treatment, and as noted, all treatment is performed using ULV techniques and with strict adherence to the product labels as determined by the USEPA guidance, which has been documented not to result in toxicity. Treatment of storm drains with pyrethroids to combat infestations is considered to be appropriate where there is the potential for adverse impacts on public health. However, storm drains are most often a problem when garbage and sediment from local streets prevent storm water from draining quickly, leaving stagnant underground pools or ponds resulting in mosquito breeding. Most often, storm drains in residential areas are treated with larvicides. Street sweeping and trash removal are physical methods of control employed by the affected jurisdictions and homeowners to minimize stagnant water under local streets; unfortunately, these practices do not occur sufficiently in every neighborhood.

Response 12

The Draft PEIR identified Chinook salmon and steelhead habitat in the Program area. Coho salmon have been added to the following paragraphs under the Physical Control Alternative (Section 4.2.4.1.1 on page 4-80), and Vegetation Management Alternative (Section 4.2.5.1.1 on page 4-87):

> "Because their rapid currents do not provide suitable habitat for mosquitoes, creeks and rivers generally do not support substantial numbers of mosquitoes, although, some mosquitoes can be found in slow eddies and back channels, or in pools isolated on the banks as flows recede. Creeks and rivers may support special-status species including steelhead, Chinook salmon, Coho salmon, foothill yellow legged frog, California red legged frog, California freshwater shrimp, and other species, as indicated in Table 4-1. Isolated ponds and back channels may provide habitat for mosquito larva, but these areas may also provide excellent rearing habitat for young fish and amphibians, as they provide warmer water temperatures, higher primary productivity and protection from predaceous fish."

Response 13

The comment repeats the assertion that the BMPs are not adequate to prevent harm to special-status aquatic species such as salmonids and other fish. This assertion is contradicted by the substantial evidence and analysis in the Draft PEIR and additional clarifications provided herein. Furthermore, the comment that food chain impacts would exacerbate a "failure to address significant impacts" is misleading. Rather, the commenter disagrees with the Draft PEIR's conclusion that impacts would be less-than-significant but does not provide any substantial evidence to refute the material analyzed in the Draft PEIR, which includes the references cited in the PEIR Chapter 17, the references cited in each Appendix, and the additional references cited here in this responses to comments including attachments.

The Draft PEIR disclosed a broad range of issues associated with chemical methods of vector control and made a reasonable good faith effort to address those issues in a manner understandable to the public by PEIR preparers with the appropriate qualifications. The issue of loss of prey and prey habitat, as well as the potential impact to contaminated prey, was addressed in the Draft PEIR and further considered by a senior toxicologist and addressed in the extensive response below to support the material in Section 4.2.2.6 or the Draft PEIR and the following statement in the Draft PEIR on page 4-75 on predator populations:

> "Mosquitoes are part of the food web and their loss may reduce the food base for some predators. Although mosquitoes serve a role as one of many types of prey items for some fish, avian insectivores, bats, and small reptiles and amphibians, the reduction of mosquito

abundance over a small area will not affect the predator populations overall, as other prey sources are available."

Because of the selective nature of the vector control products for mosquitoes, any claimed potential adverse impact to insect predators associated with District applications (as nontarget exposures) would be temporary and inconsequential in the impact to those populations of predator species. Even in the event of ancillary exposures, the recovery of such populations occurs rapidly to maintain the general level of individuals in their populations. The relative higher sensitivity of the target vs nontarget (less sensitive predator) species provides an adequate measure of safety to maintain the balance of predator populations.

Studies evaluating the toxicity of spinosad in control of *Lepidoptera*, for example, included the relation of pesticide treatment to the insect predators in the food chain. These authors reported that their studies revealed the relative safety of spinosad to natural insect predators that would likely be associated with *Lepidoptera* predation while being highly effective against the target *Lepidoptera*: "spinosad is highly active against *Lepidoptera* but is practically nontoxic to insect natural enemies." As a verification of the relative sensitivity to insects and insect predators, these authors further state that "very large direct doses of spinosad in laboratory setting were toxic to nontarget insect predators, while low doses did not exhibit the same level of toxicity to nontargets and was relatively safe against the bulk of the insect predators". (Williams et al. 2003)

It is clear that there are dramatic species differences in sensitivity to chemicals where chemicals could be applied, but one of the concerns voiced by the public about the safety of glyphosate (and other pesticides) is based on possible adverse effects or toxicity occurring as a result of bioaccumulation (uptake and sequestering of chemical in tissues) of chemical in the target species and subsequent food web transfer to nontarget predators. The processes of bioaccumulation and biomagnification (where the chemical actually becomes more concentrated in the exposed animal than the media) are processes seen primarily in the higher food web trophic levels. These processes are more typical of transfer of chemical to tissues of larger predator species and not particularly relevant to District vector control operations with pesticides and herbicides focused on insect vectors and their habitats.

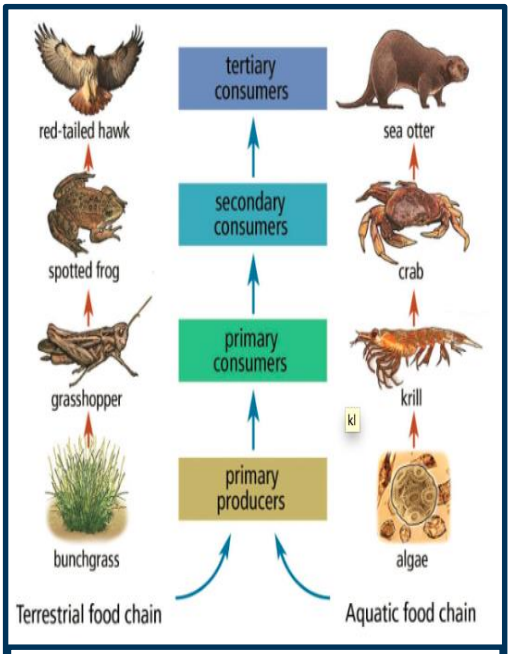
An adverse effect to nontarget predators (food web transfer of applied chemical) would require the consumption of adequate numbers of contaminated pests to reach a concentration in the predator that would be toxic. In the food web constructs, predators consume prey items that are smaller in size and mass. This is the basis for the hierarchy inherent in the classical ecological food web. This process requires consumption of adequate numbers (mass) of contaminated prey items to exceed the dose known to result in adverse effects or mortality. An example of a purposeful impact using the process in the food chain is the baiting of small mammals to reduce the numbers of large pest species (coyotes, ground squirrels, etc.). In these instances, very large quantities of the poison are introduced into the bait animal carcass where the quantity of chemical is known to cause mortality in the predator. To result in the bioaccumulation of chemical in an insect predator, the consumption of large numbers of contaminated insects would be needed to reach a level of sensitivity in the predator. Given the specificity of pesticide toxicity to the mosquito prey of potential predators (see Table 6-1 in Appendix B of the PEIR), it would not be a likely route of chemical transfer.

The approach used to address potential food web transfer (uptake) of chemicals and contaminated prey is the ecological risk assessment (EcoRA), which is a series of calculations that take into account the concentration of the exposure media, potential ingestion rates of the prey items and the predators, and the concentrations of the sources of exposure. The series of parameters used in the EcoRA food web analysis require information about each of the species of interest, the contaminants (pesticides) of interest, and demographic information for each affected species (target and nontarget). Using these data an estimate of the likelihood and amount of transfer of contaminant can be estimated. As it is obvious that there is little if any bioaccumulation of chemical in target insects, for example, the transfer to the predator would be minimal. If the target insects in this scenario are killed as planned, the minuscule amount of

chemical on the insect could be ingested by the predator. However, to reach a toxicity threshold that would result in adverse impacts to a predator bird, very large numbers would be needed: for glyphosate, for example, 2000-4000 mg of chemical would be required. This equates to approximately 800 to 1600 fully saturated (with chemical) mosquitoes and since each mosquito is not “100% chemical”, this scenario suggests that secondary toxicity is not likely.

To address the possible food web implications of pesticide applications requires the knowledge about the specific species of concern, the habitats being treated, and the concentrations of the pesticides as they are applied and on the vegetation and/or insects after application. This complex combination of parameters and the values associated with them are not usually available, so food web risk assessments are based on available demographic data, assumptions, and the numerous uncertainties associated with each. There are hundreds of possible combinations of food web interactions but the concern about the impact of insect prey on predator populations can be illustrated by the figure in the insert below depicting a simple hypothetical web at the low trophic levels.

One other food web issue is the potential to remove substantial numbers of mosquitoes (as prey items) that are required for upper trophic level species. This is roughly illustrated in the figure insert below in which the grasshopper holds the approximate terrestrial trophic position representing the terrestrial insect species and the krill represents an aquatic salt water insect species. Although it does not directly represent the food web for insects, this figure provides a graphic representation of the hierarchy of the trophic levels in a food web. Some food web depictions include dozens of interactions in a complex series of connections. In the figure depiction of a food web relationship, it is clear that removal or substantial reduction in one trophic level of the web can impact the demographics of a higher, lower, or equal trophic species. Recovery of the species impacted is dependent primarily on the reproductive replacement potential, which is rapid for the insects. Discussion of the impact of removal of the target insect species by pesticides should acknowledge the recovery potential. In most scenarios, most impacts are temporary. However, since the purposeful removal of mosquito adults and larvae at a location is the objective of vector control, the possible impact to predators must be contrasted with the objective of maintaining the public health.



A terrestrial and aquatic food chain to show the flow of the food web

Several studies have been conducted that demonstrate the likelihood that some pesticide uses are not harmful to nontarget species while showing toxicity and efficacy for the target species. In a study to compare the relative sensitivity of a pesticide to target vs nontarget species, Lawler and Dritz (2013) suggest that spinosad is an effective treatment for insect larvae that, at appropriate doses, is safe to the predators and nontarget species. While this relative toxicity study focused on spinosad, it illustrates the selective toxicity that is similar for many pyrethroids. The results reported by these authors suggest that while the impact on the target mosquito larvae was appropriately effective, the potential impact on nontarget insect populations would be minimal to inconsequential, because the doses that are effective against mosquito larvae are below levels that would even marginally impact nontarget insect populations. Even with a possible minimal impact on some of the nontarget insects, the impact would not be sufficient to adversely impact them overall. The study conclusion further supports the PEIR’s conclusion that properly selected pesticide applications can be effective against target mosquitoes while not resulting in unacceptable adverse impacts to nontarget species. The low levels of pesticides used by the District, combined with the careful

application restrictions embodied in the BMPs, results in the effective, yet environmentally compatible treatment for mosquitoes.

Moreover, inadvertent reduction of mosquito predators in a population as a result of pesticide applications conducted for vector control is a nontarget species issue only if a significant portion of the predator population is removed for an extended time. Any impact on some individuals in an insect predator population would be short lived, and population recovery would be rapid (Emlen et al. 2003). The number of insect predators impacted, when compared to the total population(s) of the predators, would be inconsequential in the long term. The relative impact on target insects versus the nontarget predators of a pesticide has been demonstrated in other studies as well. Davis et al. (2007) and Davis and Peterson (2008) evaluated the relation of target versus nontarget predators in tests using methoprene. Although these authors were evaluating methoprene, the demographics are similar as the lower toxicity to the predators would likely not have adverse species level or food web effects. Similar to the results of the studies by Davis et al. (2007) and Davis and Peterson (2008), adverse effects to a few of the individuals in a nontarget predator population as a result of typical glyphosate applications would be inconsequential.

Response 14

The concept implied in the comment that bioaccumulation always leads to toxicity is flawed. Not all pesticides bioaccumulate. Bioaccumulation is a phenomenon associated with numerous chemicals and pesticides based on extensive, long-term exposures of a product to several laboratory test species using measures of tissue concentration before and after exposures to the chemical. Additional work is often conducted in a field situation to increase the understanding of the role bioaccumulation plays in modifying the laboratory toxicity. These studies are usually conducted in the laboratory as a requirement for chemical registration, but the metabolism of methoprene in the environment reduces the amount of parent chemical available in soils (Schooley et al. 1975). Accumulation and the degree of bioaccumulation of methoprene can vary widely according to the characteristics of the exposure and the environmental conditions at the time of application.

It is correct to suggest that methoprene has been shown to be toxic to some aquatic species. It has been shown to be moderately toxic to some fish (rainbow trout); but in three studies on bluegill sunfish, the observed effects ranged from moderate to very high toxicity. It is moderately toxic to crustaceans such as shrimp, lobsters and crayfish, and freshwater invertebrates. However, these results occurred at much higher exposures of methoprene than would occur in field applications of methoprene for mosquito control. The potential adverse impact of methoprene to these aquatic species can be minimized or ameliorated by the prudent use of strict application guidelines combined with its characteristic degradation characteristics (degraded by sunlight and/or microorganisms) in the environment. Exposure of aquatic organisms will be limited by the low solubility (0.51 ppm) of methoprene in water and by its rapid degradation in aquatic environments; therefore, the impact is less than significant.

Although some of the characteristic metrics of toxicity might be of concern, the impact of methoprene in water at the diluted concentrations resulting from application for mosquito control make the potential adverse effects less likely to be of concern because the toxicity to aquatic animals occurs at levels in the parts per million range, rather than the parts per billion level that are found in likely realistic applications, including those that occur under the Program. The District's use of methoprene is not expected to result in exposures harmful to aquatic invertebrates because methoprene is short-lived in the aquatic environment, and it does not have a particularly high potential for bioaccumulation (EXTOXNET 1995). In a multi-year study conducted in wetlands, researchers found no long-term negative impact on nontarget insects apparent after 8 years of treatment, but effects were found in some years. In some years some chironomid groups were affected, but there was no detectible difference in total chironomid biomass due to treatment over 8 years in the treated vs. nontreated wetlands (Hershey et al. 1997).

"Water analyses in field and laboratory conditions and a comparison of reported Altosid (a methoprene product) use with reported frog deformities in Minnesota demonstrate that a connection between frog deformities and Altosid use is unlikely" (Henrick et al. 2002). These results indicate that factors other than s-methoprene and its degradation products are contributing to the recent outbreak of frog deformities (Henrick et al. 2002).

Response 15

This conclusory comment that BMPs are inadequate and pesticide use discussions are inaccurate, and that significant impacts will result, is a summary statement by the commenter. Preceding responses on the use of BMPs (Response 3) and on chemical use by the District provide clear and substantial evidence that the conclusions of less-than-significant impacts from the District's chemical control are technically defensible and appropriate. Additional literature was reviewed in preparing these and other responses to comments, and some of this literature review is attached to this response as Attachment A. Furthermore, the author of the responses on pesticide use herein, both insecticides and herbicides, and the ecological and human health impact conclusions and related material in the Draft PEIR, is Bill A. Williams, PhD, a toxicologist with the educational and experiential background as an expert on pesticides and their use in aquatic and terrestrial environments.

A summary of Dr. Williams' qualifications to evaluate the scientific literature and to consider where and how the pesticides are being used specifically by the District for vector control in order to draw conclusions of impact significance to humans and to nontarget species are provided below. The highlights of his extensive experience presented are from Dr. Williams' technical resume, which is attached to the end of these responses to your comments (Attachment B). This resume has been reduced from his master resume in order to focus on the most relevant aspects of his career dealing with pesticides and risk assessments, excluding his accomplishments at NASA as a Program Scientist and Payload Scientist/Astronaut (1969-1986).

Dr. Williams has more than 30 years of experience and expertise in environmental risk assessment and toxicology, including CERCLA, NRDA, NEPA, and CEQA projects ranging from upland to sediment to freshwater/marine projects. Dr. Williams has been a member of numerous international, National Academy, and federal committees and workshops to define risk assessment guidelines, test procedures, field study approaches, and avian and mammalian test protocols, and to provide other technical assistance utilized by USEPA regulators. He helped develop USEPA's Framework for Ecological Risk Assessment and USEPA's risk assessment of 2,3,7,8 TCDD (tetrachlorodibenzo-p-dioxin or dioxin). He was a charter member of the Avian Dialogue Group, convened by the Conservation Foundation (RESOLVE) to bring industry, academia, and government regulators together to resolve conflicts between the groups. Dr. Williams has led and supported dozens of successful projects that were acceptable to the Washington Department of Ecology, Oregon Department of Environmental Quality, Oregon Department of Fish and Wildlife, US Environmental Protection Agency, Region 2, 9, 10 and numerous other USEPA regions nationwide. Dr. Williams has served on several Oregon DEQ advisory science committees and workshops. He has been a member of several national and regional EPA Science Advisory Panels, including the National Science Advisory Panel on endocrine disruptors, uncertainty in risk assessments, and the panel on use of laboratory data in estimates of risk to wildlife.

Of particular relevance to his role on the CEQA documents for mosquito and vector control agencies is that Dr. Williams recently provided strategic and scientific support in the development of an Integrated Pest Management (IPM) system for use by the Mid-Peninsula Open Space District in the San Francisco Bay Area. The IPM is tailored to the vectors of concern, the pesticides and herbicides used by the District, and potential risk to the nontarget aquatic and terrestrial species. Pesticides incorporated into the IPM were based on evaluations of the use of more than 20 herbicides (with emphasis on use of glyphosate in regional wildland areas for control of over 60 invasive plant species), dozens of insecticides, structural and nuisance agricultural and urban pests, and selected regional wildlife pests. The IPM developed for

the District included control of ants, cockroaches, wasps and flies, ticks, and mosquitoes. The IPM plan included recommendations for establishing and conducting pest identification, conducting damage assessments, and establishing tolerance levels and several tiers of proposed vector control that addressed top to bottom elements of implementation strategies.

Dr. Williams also provided scientific reviews and risk assessments addressing the potential adverse effects of CAL FIRE herbicide use to reduce the potential for and mitigation of wildfires in California. The Vegetation Treatment Program (VTP) project included evaluation of potential adverse impacts of herbicides used in forestry and rangeland to control brush and grasses and for maintenance of areas that have been previously cleared of heavy vegetative fuels. The primary herbicides of concern in the evaluation were the numerous products containing glyphosate as the active ingredient.

Dr. Williams has participated in numerous workshops as a speaker or panel member on ecological risk assessment addressing such topics as uncertainty analysis in ecological risk assessments, ecotoxicological principles for avian field studies, population ecology and wildlife toxicology of agricultural pesticide use, and environmental effects assessment. He has published numerous peer-reviewed studies in scientific journals and presented abstracts in scientific meetings, including the following (of more than 9 book chapters, 55 peer review studies, and more than 105 meeting abstracts):

> Williams, B.A., J.Q. Word, and W. Gardiner. 2007. Detecting the Presence and Effects of Pharmaceuticals and Personal Care Products in Water Samples. WEFTEC Annual Conference October 11-17 September, 2007. San Diego, CA.

> Williams, B.A., J.Q. Word, and W. Gardiner. 2007. Reducing Effects of Endocrine Disrupting Compounds: Effluent Blending. Water Reuse Assoc. Conference July 29-30, 2007. Providence, RI.

> Williams, B.A., L.J. Kennedy, J.A. Nedoff, and T. Fuji. 2005. Risk Assessment as a Tool for Emerging Contaminants and Water Quality Decisions. PNW AWWA Meeting, Portland, OR, 4-6 May 2005.

> Bahe, A., B.A. Williams, L.J. Kennedy, and J.A. Nedoff. 2004. Do Residual Levels of Pharmaceuticals Contribute to Endocrine Disruption? 25th Annual Mtg. SETAC, Portland, OR, 14-18 November 2004.

> Williams, B.A., L.J. Kennedy, and J.A. Nedoff. 2003. Uncertain About Uncertainty in Environmental Risk Assessment. NorCal SETAC, Berkeley, CA, 6-7 May 2003.

> Kapustka, L.A., B.A. Williams, and A. Fairbrother. 1996. Evaluating Risk Predictions at Population and Community Levels in Pesticide Registration - Hypotheses To Be Tested. Environ. Toxicol. & Chem. 15(4): 427-431.

> Williams, B.A., et al. 1994. Assessing Pesticide Impact in Birds. Final Report of the Avian Effects Dialogue Group (1988-1993). Resolve, Washington, DC.

> Williams, B.A. et al. 1991. Assessing Pesticide Impact in Birds. Discussions of the Avian Effects Dialogue Group (1989-1991). Resolve, Washington, DC.

The substantial evidence contained in the Draft PEIR and in the Final PEIR compiled by Dr. Williams and the best professional judgment exercised by Dr. Williams in the context of this CEQA evaluation of vector control is defensible and sufficient.

Response 16

California has designated more than 1.7 million acres as critical habitat for CRLF. The District has a commitment to consider mosquito surveillance and control cautiously within CRLF critical habitat (as an effort to avoid impacts to special-status species) and to monitor and avoid/minimize chemical applications in areas that might impact them. The District's policy is to apply all pesticides according to label requirements. Although there is a potential for the applications of permethrin (or any other adulticide used), in the vicinity of unlined storm drains or as a ULV fog over wetlands, to infringe on an area of

CRLF habitat, the basic issue in all cases is not what the potential toxicity may be, as most of those data are developed in studies that purposely provide extreme levels of exposure to the chemical of interest, but whether toxicity is reasonably foreseeable under the circumstances of the proposed application. Typical methods of testing for toxicity in the laboratory are most often not representative of the potential for exposure in the field, or thus of the potential for real world impacts. The USEPA designations of toxicity are based, for the most part, on the results of these highly unrealistic laboratory exposures and serve only as guidance for use patterns and labeling to address the safety measures needed to minimize chemical exposure to nontarget species such as the CRLF. Also, permethrin use would be limited to adult insects (adulticiding), either mosquitoes or wasps/ticks. The potential for the product to actually contact CRLF is remote. Most of the District's chemical treatments are to mosquito larvae and pupae using highly targeted (rather than broad spectrum) products.

Any chemical can become toxic if the exposure (dose) is high enough to exceed the receptor's threshold sensitivity to that chemical. For many chemicals, the threshold to exhibit toxic effects is very high; for others, the threshold may be low. Since these characteristics are species and chemical specific, USEPA provides the relative toxicity data for thousands of chemical products. Tests with permethrin at high levels in the laboratory suggest that it can, at high doses, adversely affect the aquatic and terrestrial phases of the CRLF. However, the concern about this pesticide should be compared to the potential for exposure in the actual field conditions and habitat and identification of the confounding factors that can contribute to the adverse effects in the CRLF. CRLF can occur in any freshwater aquatic habitat, including stagnant ponds and roadside ditches. This is primarily for juvenile and adult frogs. This species can move a considerable distance (2 miles or more) away from breeding habitats so could occur in aquatic habitats other than breeding habitats. Eggs and larvae are unlikely to be present in small ditches or stagnant ponds unless other breeding habitat is not available and if water quality is suitable.

Peer reviewed and published reports that suggest a link between permethrin applications and CRLF survival or impacts include confounding factors that cannot be ruled out as part of any observed effects (Kiesecker et al. 2001). Rather, the concerns for this endangered amphibian are linked to indirect relationships that are subject to numerous confounding factors (Kiesecker et al. 2001) that also may contribute to adverse effects to the species at early life stages (Johanssen et al. 2006). Clearly, water quality issues and other environmental conditions provide a substantial number of other factors that may impact the CRLF populations (Adams et al. 2013). Amphibian populations are known to be adversely impacted by viral infections and parasites as illustrated by studies of amphibians in pristine, elevated regions far from the potential impact of these chemicals.

The USFWS has identified and documented the following nonpesticide confounding factors that adversely affect the CRLF. The following confounding factors in the interpretation of adverse impacts to CRLF are provided by the California Department of Fish and Game (CDFG 2002):

> In Coastal lagoons, the most significant mortality factor in the pre hatching stage is water salinity.
  - 100 percent mortality occurs in eggs exposed to salinity levels greater than 4.5 parts per thousand.
  - Larvae die when exposed to salinities greater than 7.0 parts per thousand.
> Predation is an important factor. Bitterns (*Botaurus lentiginosus*) and Black Crowned Night Herons (*Nycticorax nycticorax*) are likely predators of adult frogs. Juvenile frogs, which are more active diurnally, and less wary than adults, may be more susceptible to predation by diurnal predators, such as the Great Blue Heron (*Ardea herodias*) and several species of garter snakes (*Thamnophis* sp.), including the endangered San Francisco Garter Snake (*Thamnophis sirtalis tetrataenia*).

These confounding factors make establishing pesticide causality nearly impossible, especially at the potential exposure that could result from the District's use under the Program.

For a discussion of potential chemical effects on prey, see Response 13. When considered in light of the evidence and analysis in the PEIR, there is no substantial evidence that the occasional application of

permethrin in accordance with label requirements and BMPs would have a substantial adverse effect on individual CRLFs or CRLF populations in general, either directly or as a result of changes to CRLF critical habitat.

Response 17

Some reports cited by the public suggest that the potential impact of glyphosate and glyphosate products includes adverse impacts to several life stages of amphibians and their habitats. These reports are not directly relevant to the potential impact of glyphosate on the CRLF in the environment as the data presented is based primarily on toxicity in laboratory studies using both high doses and several sequential lower doses in a laboratory setting. The toxicity of glyphosate to dozens of species are listed in Table 6-1 of Appendix B.

While the addition of some surfactants to glyphosate products may make the products more toxic to some biota, the primary concern for red-legged frog is toxicity based on studies using high, continuous exposures to the products in laboratory tests. The exposures in the laboratory studies are clearly not representative simulations of the potential exposures in field applications because the laboratory studies involve captive test species, unable to choose uncontaminated food or habitat. Many laboratory tests are designed and conducted to determine the 'worst-case" exposure to a chemical and then to lower the test concentrations slowly until a test concentration shows no adverse effect to the test animals (USEPA 2012a; Williams et al. 1994). In this way, the concentrations that produce exposures with little or no adverse response can be documented and used to define the applications that should be safe to the animals and environment. As in all of the relevant laboratory toxicity studies, the exposures in laboratory conditions are essentially 100 percent with no ability to choose areas of lessor concentrations, and use of nonrepresentative exposures.

The primary causes identified by the US Fish and Wildlife Service as leading to an adverse impact on the status of the threatened California red-legged frog are loss of habitat and overwhelming predation, invasive species, and competition for foraging items (National Wildlife Federation listings). The potential impact of glyphosate on the CRLF is marginal and only applicable in situations of excess exposure to incorrectly treated areas. The toxicity and adverse effects reported in laboratory studies would not be expected to occur as a result of the District's potential herbicide applications for mosquito or invasive species control in the field, because of the much lower potential exposures and the District's adherence to its BMPs. Special care is taken to avoid applications where CRLF have been identified and reported by resource agency personnel or District biologists and technicians based on observations and database investigations.

Reports on the effects of glyphosate to amphibians and other nontarget wildlife using mesocosms (outdoor studies in confined ponds) is intended to extend the results of the laboratory studies to more realistic environmental conditions by providing exposures in outdoor pond systems. However, even in these reports, the exposure parameters far exceed the possible exposure (dose) that would be received by amphibians in a real environmental applications by the District that are far below these concentrations. An example of mesocosm studies, the report "The Lethal Impact of Roundup on Aquatic and Terrestrial Amphibians" by Rick A. Relyea published in Ecological Applications, 15(4), 2005, pp. 1118–1124, provides "more realistic" exposures, but the potential effects to CRLF suggested by this author are neither appropriate to the CRLF habitats nor to the spatial and temporal exposures that would occur in the environment. The exposures used were based on direct overspray of the mesocosm units, which is completely unrealistic if the author intends to extrapolate the results to reasonably foreseeable field exposures. The applications used in the Relyea report resulted in considerably more potential exposure to the test species than would be expected with typical District applications. The direct overspray of the mesocosm is in sharp contrast to the targeted, hand applications that are typical of the more focused and directed herbicide applications utilized by the District than the broad area applications used in agricultural operations.

In response to the concerns about the potential impact of glyphosate and its product formulations on the CRLF, the USEPA developed a comprehensive risk assessment for all of the potential application scenarios that might encounter the CRLF or its habitat. Using the most conservative (high) applications and several typical (more realistic) application scenarios, the USEPA has reported that glyphosate "may affect" the CRLF if they are exposed at very high concentrations of glyphosate (and also its formulation ingredients, including surfactants). This determination is based on computer models that use assumptions of application rates from the highest known (generally industrial and some urban uses) to the rates likely more appropriate for District uses. The risk assessment produced by the USEPA was published in "Risks of Glyphosate Use to Federally Threatened California Red-legged Frog (*Rana aurora draytonii*)" in 2008. In this 180-page exercise, the potential effects of glyphosate were modeled and risk estimates generated for almost every conceivable exposure to the CRLF and its prey items and habitats. The results of this comprehensive computer study suggest that at high rates of application (well above the rates used by the District) some adverse impacts may be possible, but the overall conclusions about the potential risks suggest that the nominal rates used by the District are likely to result in minimal to no effects. For example, some of the conclusions provided in the report by the USEPA include the following:

> **Direct Effects:** When used for habitat modification (vegetation control) the acute and chronic Level of Concern (LOC) for freshwater invertebrates are not exceeded for glyphosate, its salts or formulations. In addition, the analysis indicates that the probability of an individual effect and the percentage effect to the freshwater invertebrate population prey base would be very low.

> **Indirect Effects:** The acute and chronic LOCs for freshwater invertebrates are not exceeded for glyphosate, its salts or formulations. In addition, the analysis indicates that the probability of an individual effect and the percentage effect to the freshwater invertebrate population prey base would be very low, and the field monitoring data available are considerably lower than the modeled concentrations utilized in the risk assessment.

> **Terrestrial prey items, riparian habitat:** For terrestrial invertebrates, the upper bound Risk Quotients (RQs) for small insects exceed the LOC for listed terrestrial invertebrates for all uses and for nonlisted terrestrial invertebrates at very high (much higher than used by the District) application rates above about 8 lbs active ingredient (a.i.)/Acre. In other words, the guidance and risk estimates are based on estimates of worst-case exposures that are well beyond the applications used by the District. However, at the lower upper bound USEPA derived RQ (<0.01 with 0.4 lbs a.i./Acre), the chance of an individual effect is less than 1 in 9×10^{18} (eighteen zeros) and about a chance of less than 1×10^{-17} (that is seventeen zeros) percentage effect to the terrestrial invertebrate prey base. These calculations by the USEPA support the contention that chances for an adverse impact are nearly zero.

> **All other uses** at application rates below about 4 lbs a.i./Acre have no effect designation: (according to the USEPA risk assessment, this applies to all crops, forestry and impervious surfaces at lower rates, rangeland, residential, rights of way at lower rates and turf).

All chemicals can cause adverse effects or even become toxic at levels exceeding the tolerance and sensitivity levels for that species. However, the sensitivity and tolerance levels are determined by the USEPA and other regulatory agencies using laboratory tests with numerous species of concern that are estimated to be potentially exposed to an application. The results of these tests on each chemical are published in numerous publically available USEPA documents summarizing the testing results with metrics such as the LD_{50}, LC_{50} and maximum estimated tolerance levels. For glyphosate, these metrics are indicated in detail in Appendix B (Section 4.6.2) of the PEIR and support the fact that District use levels are far below those that could result in an adverse impact.

While the referenced USEPA risk assessment for glyphosate provides some valuable information about the potential for adverse effects to CRLF, the conclusions include identification of the numerous areas where there are uncertainties (and the risk assessment uses large uncertainty or safety factors). However, it clearly indicates that the use of glyphosate and its formulations should be considered relatively safe to the CRLF if

care is taken in the selection of areas for application, use of the recommended application rates, and prudent prior assessment of areas that may contain CRLF or its habitat.

Response 18

The comment maintains that while vector control programs are exempt from the injunction, this is a separate issue from whether the Program is likely to have a significant impact on CRLF. Specifically, for applications of a pesticide for purposes of public health vector control under a program administered by a public entity, the injunction does not apply.

The injunction is part of the regulatory setting for the aquatic and terrestrial biology chapters of the PEIR. It should be included in the environmental setting because it shows that use of the chemicals of concern to CRLF may be reduced, which is important in addressing cumulative impacts. Some previous users of these materials may switch to other nonlisted pesticides rather than comply with the no-use buffer zones established under the injunction. For those other users that do comply, the buffer zone is an effective measure for minimizing the effect of the active ingredients on CRLF. The presence of the injunction does not require a determination of significant impact because the vector control applications must be considered in the context of their use. The listed pesticides do not include permethrin; esfenvalerate and methoprene are the only listed materials included in the District's IVMP. The text on page 4-42 has been corrected as indicated below.

> Of the 66 pesticides listed in the injunction, the District may employ esfenvalerate~~,~~ and methoprene, ~~and permethrin~~ for vector control. Esfenvalerate may be used for yellow-jacket and wasp control in response to public complaints. Methoprene is used for larval mosquito control ~~and permethrin is may be used for adult mosquito control~~. However, vector control programs are exempt. Specifically, for applications of a pesticide for purposes of public health vector control under a program administered by a public entity, the injunction does not apply. The District may use the following herbicides listed in the injunction: glyphosate, imazapyr, and triclopyr. Where used for vegetation management for control of mosquito-breeding habitat, the injunction would not apply.

Esfenvalerate is a Type 2 pyrethroid that would be used by the District only for yellow jacket wasp and ticks primarily in recreation areas. Because these applications do not occur in areas where CRLF may be significantly exposed, esfenvalerate use under the Program would not pose a risk to CRLF or other amphibians. More information about esfenvalerate is included in Appendix B, Section 4.1.6. Methoprene is a mosquito larvicide/insect growth regulator discussed in detail in Appendix B, Section 4.3.4 and in the PEIR Section 6.2.7.1.2 that is widely used by the District for mosquito control but used at rates that do not present a significant toxicity risk to aquatic species, including amphibians. See also Response 14.

Response 19

The commenter is concerned about pesticide runoff from vector control applications, through storm drains or otherwise, resulting in significant toxicity to CRLF. To reduce potential pesticide contributions to urban and/or industrial drains and collector ponds/catch basins from vector control applications, the District follows an integrated pest management (IPM) approach that strives to minimize the use of pesticides and their impact on the environment while protecting public health. Storm drains become a mosquito-breeding problem when water is trapped and stagnates, not during the rainy season when the drains are flushed frequently. Also see the portions of Response 11 and Response 16 addressing storm drain management.

As discussed in Section 2.3 of the PEIR, the District employs IPM principles by first determining the species and abundance of mosquitoes/vectors through evaluation of public service requests and field surveys of immature and adult mosquito/vector populations and, then, if the populations exceed predetermined criteria, using the most efficient, effective, and environmentally sensitive means of control. For all mosquito species, public education is an important control strategy for minimizing or avoiding

mosquito-breeding conditions on private property. In some situations, water management or other physical control activities can be instituted to reduce mosquito-breeding sites. In some cases, the District can also use biological control such as the planting of mosquitofish in ornamental fish ponds, water troughs, water gardens, fountains, and unused swimming pools. When these nonchemical approaches are not effective, or are otherwise deemed inappropriate, then pesticides are used to treat specific vector-producing or vector-harboring areas.

When pesticides are applied, the District implements label requirements and BMPs to reduce adverse effects to surface-water and groundwater resources during and following pesticide applications. For example, some pesticide labels restrict applications within 24 hours following rain events or in areas where intense or sustained rainfall is forecasted to occur within 24 hours following application. In such cases, the District would not apply pesticides until weather conditions are appropriate. Adulticides are never applied when it is raining because the mosquitoes are not as active and the droplets do not stay suspended, limiting the effectiveness of the product. The adulticide is not applied directly to the water but in micron sized droplets above the water's surface, which minimizes the amount of active ingredient that actually reaches the water surface. See Draft PEIR Section 9.2.7.2 on this issue of adulticides and water quality. For the larvicide methoprene, which may be applied in liquid or granular forms directly to wetlands or aerially (from the ground) to reach larvae in the water, see Section 9.2.7.1.2 of the Draft PEIR.

The mobility and environmental fate of a particular pesticide is influenced by its chemical properties and by the environmental conditions in which it is applied, and these factors influence potential exposure in the field to nontarget organisms. The PEIR's Appendix B, Ecological and Human Health Assessment Report, provides a detailed description of the fate and transport in air, water, and soil for each of the active ingredients in products applied by the District (as well as some others not used by the District). Many second- and third-generation insecticides are formulated to act quickly and then dissipate quickly in the environment, often within hours or days. Others bind to soils and sediments where they are degraded abiotically or by soil organisms. These effects, the application methods used for vector control, and the potential for mobilization after pesticide application, are considered in the discussion of the Vegetation Management and Chemical Control Alternatives, which conclude that all of the active ingredients included in the Proposed Program would not significantly impact surface water or groundwater (see Sections 9.2.5 and 9.2.7 of the PEIR), or aquatic species (Sections 4.2.5 and 4.2.7 of the PEIR). For each of the pesticides used by the District there is minimal movement of pesticides in sediments or soils into water bodies due to the binding and half-life characteristics of the chemical used.

Response 20

Please refer to Response 22 below.

Response 21

The persistence of glyphosate is dependent on the physical/chemical conditions of the soils and vegetation treated, and the impact of the chemical on the rhizomes and the plant root system is not continual or at levels of contact that would result in the suggested toxicity to the root system. The paper by McNear 2013 is a good introductory compendium of the role and structure of typical root systems, but has no clear relation to the potential toxicity of chemicals such as glyphosate after an application to the surface soils and/or vegetation. The results of studies on the root systems exposed after glyphosate application suggest that the complexity of a root system may possibly be impacted by direct exposure (Barberis et al. 2013), but this is neither a typical nor likely exposure based on the District's potential uses of glyphosate products because the District would be directly applying the material to the above ground foliage. The applications target the unwanted vegetation, not indiscriminate application. It would be the exception that the District would be involved in a large scale application (e.g., dozens of acres). If the District were to be involved in an herbicide application, it would most likely be small scale and using hand equipment, truck or ATV based equipment. Regardless of this potential toxicity, there is no clear, direct

association to toxicity to the root systems when glyphosate is applied for vector management according to District uses. Direct exposures in laboratory studies do not provide realistic exposures when a chemical is applied in the field (Williams et al. 1994).

For decades, scientists have demonstrated and validated that every organic chemical has a physical/chemical degradation characteristic termed “half-life” (a metric used to describe the elapsed time for a chemical to reach ½ of its initial activity). Each organic chemical, whether toxic or not, decays in both activity and toxicity over time. For some chemicals, the half-life can be hours, days, or weeks. By design, few chemicals used as pesticides[1] have half-lives greater than a week and are further degraded by the environmental conditions of the application area. When pesticides get into soil, or water, or are taken up by plants and animals, the half-life characteristics are altered. The environmental fate of pesticides depends on the physical and chemical properties of the pesticide, particularly the pH of the medium, modifying how likely it is to travel through soil (soil mobility), how well it dissolves in water (water solubility), and how likely it is to become airborne (volatility).

Once a pesticide has been released into the environment, it can be broken down by exposure to sunlight, (photolysis), exposure to water (hydrolysis), exposure to other chemicals (oxidation and reduction), microbial activity (bacteria, fungi, and other microorganisms), and other plants or animals (metabolism). Pesticide labels set out safety and use guidelines that usually focus on three aspects: rates of application (single and cumulative) for registered crops and pests, timing of application, and restrictions on areas of application (including required buffer zones).

The environmental fate of pesticides used by the District are influenced by their chemical properties and by the environmental conditions in which they are applied. The PEIR’s Appendix B, Ecological and Human Health Assessment Report, provides a detailed description of the fate and transport in air, water, and soil for each of the active ingredients applied by the District (and other active ingredients as well). A summary of the potential uses of glyphosate products by the District is included in Appendix B Table 6-1 and the narrative in section 4.6.2 of Appendix B. Many second-and third-generation pesticides are formulated to act quickly and then dissipate quickly in the environment, often through photolysis or microbial breakdown. Others bind to soils and sediments where they are degraded abiotically or by soil organisms. These effects, the potential for mobilization after pesticide application and the methods used to minimize exposures to unwanted receptors, are considered in the discussion of the Vegetation Management and Chemical Control Alternatives (see Sections 9.2.5 and 9.2.7 of the PEIR).

There are numerous herbicide products (such as Roundup) using the active ingredient glyphosate as its primary constituent, but many of these products use inert and/or chemically different additives to enhance the spray characteristics, adhesion properties, and efficacy. Many of those products have been specially tested for toxicity and registered with the USEPA for specific vector control purposes, including vegetation control (National Park Service 2008). Although some of these mixture products have been associated with increased toxicity, numerous studies have demonstrated that the increase in toxicity may be due to a surfactant additive. In most instances, these special formulations of pesticide products are intended to reduce the potential for adverse effects or to specifically be used for aquatic environments (e.g., Accord, which has been shown to be safer to aquatic wildlife (Brodman et al. 2010)).

Many reports suggest that exposure to glyphosate may be toxic at sub-lethal levels, negatively impacting the basic physiological systems of animals in several trophic levels. However, most studies directed specifically at these systems have resulted in unequivocal results without clear causal effects. In one study on the effects of several (six) concentrations of glyphosate on growth rate and aflatoxin B1 (AFB1) production by Aspergillus section Flavi strains under different water activity (aW) on maize-based medium. In general, the authors report that at high concentrations glyphosate significantly increased the growth of all Aspergillus section Flavi strains. Aflatoxin B1 production did not show noticeable differences

[1] The term “pesticides” includes herbicides used for destroying weeds and other unwanted vegetation.

among different pesticide concentrations assayed at all aW in both strains. This study has shown that these Aspergillus flavus and A. parasiticus strains are able to grow effectively and produce aflatoxins in high nutrient status media even at a large range of glyphosate concentrations under different water activity conditions thereby indicating no negative effect. (Barber's et al. 2013)

Glyphosate has been shown to have a half-life of a few days in some conditions to longer in some soils. The generally accepted, conservative, half-life for soils is reported to be approximately a month to 42 days, depending on the soil type, pH, and other characteristics of the soils. Vegetation residues of glyphosate have been measured in numerous studies, and it is typical that the measurable residue of glyphosate in target vegetation diminishes rapidly after incorporation into the plant tissue (Zhang et al. 2015). Glyphosate changes from the primary chemical to the lessor resulting product chemicals. The half-life denotes the time for the parent compound to decrease in detectable concentration by ½ the application concentration essentially halving the exposure concentration available. When applied to typical areas targeted for vegetation management, glyphosate is transformed to less toxic and different chemical constituents in normal soil within a few days, or even quicker when used for most general uses such as those by the District. It can be rapidly bound to soil particles and inactivated, and the unbound glyphosate can be degraded by bacteria.

Response 22

Comment 22 asserts the Draft PEIR of "downplays glyphosate's risks to human health." The PEIR preparers (including Dr. Williams) evaluated numerous studies on glyphosate, the World Health Organization (WHO) report, and scientific reviews of the WHO report in determining that potential use by the District poses a less-than-significant impact on human health. The WHO report is the result of a "panel discussion" (IARC) about the potential for selected chemicals and products that have achieved some level of public interest and concern but may or may not be supported by the data and information available. The panel is comprised of several European scientists and government organizations reporting to the WHO (a scientifically conservative advocacy agency) sponsored by the UN. This group is known to generally follow the "precautionary principle" that is used by some members of the public to argue against chemical use. The precautionary principle is a concept generally rejected by the scientific community that demands that unless one can prove there is or can be no adverse impacts of a substance, the substance should be considered hazardous (Precautionary Principle objective). To those with scientific training, this suggests that one must "prove a negative" which is essentially impossible in any statistical sense of a defensible scientific process.

The IARC has been criticized by dozens of technical experts who evaluated the process used by the panel to list glyphosate as a probable carcinogen. It has been demonstrated that IARC rejected the 800 studies / 3,000 documents that gave glyphosate a positive safety result, basing their decision of "probably carcinogenic" on only eight studies, of which three actually included results that were themselves arguably insignificant. After the WHO publication listing glyphosate as a probable carcinogen, dozens of practicing scientists in the mainstream scientific community (including European Food Safety Administration, the German Federal Institute for Risk Assessment (BfR) and the lead author of one of the studies used by IARC to draw its conclusions) have criticized and disputed the results of the IARC for using a poor methodology and inadequate research. The conclusions drawn by the IARC about the potential adverse effects of glyphosate were based on studies that are not relevant to actual, potential exposures and on studies that were based on high exposures to petri dish cells and in vitro laboratory conditions. Once again, the precautionary principle requires "proof of a negative" which requires that the studies disprove any possible negative effect in order to accept the results of a study.

In most of its reported reviews, the UN IARC has advocated the precautionary principle (WHO 2015). Subsequent to the declaration regarding glyphosate, this panel stated that bacon and other animal products are "possibly carcinogenic;" again, the declaration was challenged by several scientists who

reiterated that there was no credible research that was clear enough to make such a claim (WHO 2015; Mink et al. 2012).

Glyphosate exposure was not associated with cancer incidence overall or with most of the cancer subtypes studied by de Roos et al. (2005). Given the widespread use of glyphosate, and the paucity of information providing significant and relevant causality amid the nonscientific claims that glyphosate exhibits numerous low-level or sub-lethal adverse effects (Seneff nd), Dr. Williams concluded that there have been no demonstrated significant adverse health effects (even in pesticide applicators). The studies reporting potential human health effects are associated with extreme exposures to applicators during misuse scenarios and spills and/or working in the preparation of the commercial products (Mink et al. 2012). These conditions and potential exposure conditions are neither typical nor likely in the use and applications by trained District staff. All application directions include detailed procedures to deal with a spill. Glyphosate remains a reliable and safe product for use in the numerous situations where control of vegetation is needed for habitat management (for vector control or for invasive species control). Importantly, it has been demonstrated that herbicides are a different class of chemicals than those classified as insecticides that have specific, demonstrated autonomic effects. The media reports about the hazards of glyphosate and its several commercial products have not been clearly associated with human health. The numerous reports about “possible” connections to metabolic processes and subtle effects also include confounding factors that make scientifically defensible claims impossible. Where there are reports of adverse subtle effects, they are usually based on laboratory studies of cell lines etc., at exposures far above any possible actual human exposure.

USEPA continually reviews the available scientific data and other relevant information in support of the registration of glyphosate (i.e., commercial product Roundup for weed control) and has indicated that there are sufficient data to assess the hazards of and to make a determination on aggregate exposure for glyphosate including exposure resulting from the tolerances established by continued USEPA evaluations. USEPA’s assessment of exposures and risks associated with glyphosate are clearly indicated in the numerous studies used to develop the guidance for use. Using these data, the EPA has set maximum safe exposure levels for both humans and animals (tolerances) of pesticide residues for crops based on the huge number of scientific studies and complex risk assessment approaches provided in support of the active ingredient in the products. These tolerances are hundreds of times higher than estimated toxic values using total exposure values to pesticides (including safety levels to protect children and others who may be vulnerable). The USDA tests crops each year to make sure tolerance levels are not exceeded. Very few pesticides are found above the tolerance levels (despite some unsubstantiated media reports). The exposures that were used in the WHO evaluation and studies were not reasonable examples of the exposures that might be encountered by humans, including those who might be potentially exposed as a result of the District’s use of glyphosate under the Program. US Environmental Protection Agency (USEPA) 1993 and National Pesticide Information Center, Oregon State University 2011. There are occasionally media reports of studies linking glyphosate to cancers of various types, but these are generally results from cultured cells in the laboratory. Extrapolation of these very high dose laboratory studies to animals and humans are not reliable indicators of potential adverse effects outside a controlled laboratory study.

Response 23

This comment suggests that chemicals, including those that bind to soils and exhibit subsequent mobilization and those that run off from urban storm drains and gutters after vector control applications, and would cause TMDL exceedances for some Pesticide-Related Toxicity in Urban Creeks.

The Basin Plan (SFBRWQCB 2015) establishes a water quality attainment strategy and TMDL for some pesticides and pesticide-related toxicity in the San Francisco Bay Region’s urban creeks, including actions and monitoring necessary to implement the strategy. The TMDL notes that pesticides “enter urban creeks through urban runoff. Most urban runoff flows through storm drains owned and operated by the

Region's municipalities, industrial dischargers, large institutions (e.g., campuses), construction dischargers, and the California Department of Transportation (Caltrans)." The TMDL further notes that "pesticide use by structural pest control professionals and use of products sold over the-counter can be among the greatest contributors of pesticides in urban runoff." Rather than establish mass loads for pesticide contributions, the TMDL establishes concentration-based numeric targets, expressed in concentration units, and states that "the numeric targets, allocations, and implementation plan described [in the TMDL] are intended to ensure that urban creeks meet applicable water quality standards established to protect and support beneficial uses." The TMDL's pesticide toxicity targets are expressed in terms of acute toxic units (TUa) and chronic toxic units (TUc) and require demonstration of a statistically significant observable effect. An undiluted ambient water or sediment sample that does not exhibit an acute or chronic toxic effect that is significantly different from control samples on a statistical basis shall be assumed to meet the relevant target. The TMDL implementation plan relies heavily on actions by the agencies with the broadest authorities to oversee pesticide use and pesticide discharges, including USEPA, the California Department of Pesticide Regulation, and the Water Board as well as adherence to integrated pest management (IPM) strategies. The TMDL notes that "regulatory and nonregulatory actions are needed to ensure that pesticide use does not result in discharges that cause or contribute to toxicity in urban creeks. Implementing these actions is expected to ensure attainment of the allocations. Many entities are already implementing these actions." The actions identified in the TMDL focus primarily on addressing water quality concerns through the pesticide registration process (through which label requirements are developed), and reducing the use of pesticides, including the potential for urban runoff to enter creeks, through integrated pest management. In particular, to prevent pesticide-related toxicity in urban creeks the TMDL states that mosquito and vector control agencies should "adopt IPM and less toxic pest control techniques so pesticide applications do not contribute to pesticide runoff and toxicity in urban creeks."

The District's Program is based on the principles of IPM and prioritizes nonchemical control over pesticide use. Furthermore, all District applications of chemicals are done in strict compliance with label requirements, BMPs (many of which have been developed in consultation with regulatory agencies) and applicable permit conditions (such as those contained in the Statewide NPDES Vector Control Permit (SWRCB 2011), by trained professionals. Thus, the District's existing and Proposed Programs implement the actions specified in the TMDL to ensure attainment of the TMDL's pesticide allocations. (Note that the District does not use pesticide products containing diazinon.) The District has, for at least the past two decades, taken an integrated systems approach to mosquito and vector control, utilizing a suite of tools that consists of public education, surveillance, source reduction (e.g., physical control, vegetation management, water management), biological controls, and chemical controls. As stated in PEIR Section 2.3, three core tenets are essential to the success of a sound Integrated Vector Management Program (IVMP).

> **First**, a proactive approach is necessary to minimize impacts and maximize successful vector management. Elements such as thorough surveillance and a strong public education program make all the difference in reducing potential human vector interactions.

> **Second**, long-term environmentally based solutions (e.g., water management, reduction of harborage and food resources, exclusion, and enhancement of predators and parasites) are optimal as they reduce the potential pesticide load in the environment as well as other potential long- and short-term impacts.

> **Lastly**, utilizing the full array of options and tools (public education, surveillance, physical control, biological control, and when necessary chemical control) in an informed and coordinated approach supports the overall goal of an environmentally sensitive vector management program.

To reduce potential pesticide contributions to urban and/or industrial drains and collector ponds/catch basins from vector control applications, the District follows the IPM approach and strives to minimize the use of pesticides and their impact on the environment while protecting public health. As stated in Response 19 above, unless specific vector control is required, based on surveillance results, to reduce

adult mosquito populations, District applications of adulticides are not directed to urban storm drain systems. However, larvicides, per the product labels, may be applied to urban storm drains systems to control larval mosquitoes. Chemicals introduced to urban storm drains from runoff are usually the result of city, homeowner, or landscaper discharges within or near populated areas. In addition, buffers may be used between pesticide and herbicide use areas to address the potential migration of a pesticide and waterbodies. The product label may include specific, region or state specific buffers where they are required. The District adheres to all label requirements for its specific uses.

Further support, for the PEIR conclusions of less-than-significant impacts to water quality from adulticides and larvicides applied by the District, is provided in a 2-year monitoring study conducted for the State Water Resources Control Board by the Mosquito and Vector Control Association of California (MVCAC) monitoring coalition to determine whether vector control activities were contributing contaminants to state waters. The MVCAC monitoring coalition conducted chemical monitoring for adulticides at 61 locations during 19 application events in 2011 to 2012 and coordinated physical monitoring for 136 larvicide application events in 2012. Samples were collected from agricultural, urban, and wetland environmental settings in both northern and southern California. Adulticides evaluated included pyrethrin, permethrin, sumithrin, prallethrin, etofenprox, naled, malathion, and the synergist piperonyl butoxide. The monitoring study (MVCAC 2013) was conducted in accordance with the Statewide NPDES Vector Control Permit (SWRCB 2011) and had the following results:

> 1 out of 136 visual observations showed a difference between background and post-event samples;

> 108 physical monitoring samples showed no difference between background and post-event samples; and

> 6 out of 112 samples exceeded the receiving water monitoring limitation or triggers.

The report concluded that there was no significant impact to beneficial uses of receiving waters due to application of vector control pesticides in accordance with approved application rates. This is consistent with the primary mandate for vector control districts of protecting public health by reducing vector-borne diseases from mosquitoes and other vectors.

The State Water Resources Control Board evaluated the results of this study (MVCAC 2013) and a concurrent toxicity study conducted by researchers from UC Davis (Philips et al. 2013) and concluded that, based on the monitoring data, the application of pesticides in accordance with approved application rates does not impact beneficial uses of receiving waters (SWRCB 2014). Therefore, the monitoring and reporting program for the Vector Control Permit was amended in March 2014 to limit the required monitoring to visual observations, monitoring and reporting of pesticide application rates, and reporting of noncompliant applications.

Concerning pesticide quantities, the District monitors its pesticide application rates, records this information on pesticide application logs, and reports its product use to the Marin and Sonoma County Agricultural Commissioners. The District also reports its pesticide use and application rates to the State Water Resources Control Board. The PEIR reports on pesticide use quantities in Chapter 13 (Table 13-2) based on these submittals and in Appendix B, Attachment A.

Concerning concentration, BMP H3 states: “Materials will be applied at the lowest effective concentration for a specific set of vectors and environmental conditions. Application rates will never exceed the maximum label application rate.”

Response 24

This air quality comment questions the mitigation measures as being voluntary and not mandatory. The language excerpt is not quite accurate. This response will clarify the PEIR language and make appropriate text changes to page 10-32 and elsewhere.

First of all, the objectionable odors impact statement characterizes the impact as **potentially significant but mitigable**, while the comment incorrectly quotes the statement as just being *potentially significant*. This significance determination terminology is explained in Section 1.7 (page 1-21).

Second, the comment mischaracterizes the mitigation requirements established in the PEIR. On page 10-32, the PEIR states: "To mitigate Impact AQ-25, the District and its contractors may implement any of the following measures as applicable to the specific application situation to reduce drift towards human populations/residences from the ground and aerial application of odorous treatment compounds." This statement is followed by a description of Mitigation Measures AQ-25a, AQ-25b, and AQ-25c and the conclusion that "Use of any one of these measures would reduce the impact to **less than significant**." Therefore, implementing all of these mitigation measures is not mandatory, nor are they all required in a specific application situation in order to reduce the significant impact associated with objectionable odors to less than significant. Implementing any one of the measures would, however, be mandatory. There are 3 options to allow for what is most prudent to use for the specific application. The use of the phrase "may implement" refers to the ability of the District to choose the appropriate measure; it was not meant to imply that the District may choose to implement none of the measures, just any one of the measures is sufficient as a minimum. To be clear on the point, the words "may implement" and "any of" will be changed to "shall implement one or more of the following measures as applicable" to avoid the implication that the measures are all voluntary. At least one of the measures is required. The following text change on page 10-32 will be carried into Section 10.2.11 (page 10-41) and Summary Table S-2 (page S-15).

> "To mitigate Impact AQ-25, the District and its contractors ~~may~~ shall implement ~~any~~ one or more of the following measures as applicable to the specific application situation to reduce drift towards human populations/residences from the ground and aerial application of odorous treatment compounds:"

The mitigation measures are not vague or voluntary, nor are they unenforceable. Each measure includes a description of the procedures to be followed in order to minimize the potential for drift into populated areas, location where the mitigation measure would be implemented, monitoring/reporting action to ensure the measure is implemented appropriately, criteria to assess the effectiveness of the mitigation measure, agency responsible for implementing the measure, and timing of its implementation. Thus, sufficient detail is provided to ensure that the mitigation is applied in the appropriate location at the appropriate time and by the appropriate entity; and measures also are included to document the effectiveness of the mitigation. By providing defined measures to limit the time, location, method and drift of chemical applications, the mitigation is sufficient to support the PEIR's determination that the Program's use of chemicals, as mitigated, would not create objectionable odors affecting a substantial number of people.

The commenter suggests that the "DPEIR could also require notification to residences"; however, this would not specifically mitigate the impact. District staff are available to address complaints by the public, and the effectiveness criteria for each of the measures include "Document odor complaints from the public." The public calls the District to complain about mosquitoes, so if there were an odor problem at the time a District truck was in the area, then based on the District's experience, concerned residents would be likely to call the District if there was an odor problem not easily identified as a sewer, gas leak, or farm-related odor. The mitigation measures are therefore written appropriately, and no modifications are required.

Response 25

The comment asserts that the "conflation of BMPs and mitigation measures makes it impossible … to understand the severity of the Program's cumulative impacts and subsequently, the potential for and effectiveness of any mitigation measures."

Please refer to Response 3 above. In short, the BMPs are an integral part of the District's current Program, are to be continued into the future, and are properly treated as part of the Proposed Program

being evaluated in the PEIR. To not consider them means the PEIR would overstate the impacts and be inappropriately speculative because there is no evidence that the District wants to abandon these procedures or that the responsible agencies who grant the District permits would want the District to abandon these practices in future permits, although some may be modified to respond to changing conditions. The cumulative impact analysis provided in the Draft PEIR is a thoughtful analysis of regional environmental concerns and whether any of the Proposed Program's less-than-significant impacts are cumulatively significant in the larger area context appropriate for a programmatic EIR.

Response 26

The comment that the discussion of cumulative impacts on pollinators is flawed because it contains "factually incorrect information on Colony Collapse Disorder (CCD)" is addressed first in the response below, followed by a discussion of the larger comment on coverage of pollinator impacts.

As an initial matter, the comment does not identify any specific factual assertions that it claims are incorrect, thus a specific response to the argument that the PEIR contains factually incorrect information on CCD cannot be provided. Although the District does not use neonicotinoid products, a discussion of the potential contribution of these products to cumulative impacts on pollinators, including possible CCD, was included in the PEIR because it is relevant to their potential role in a cumulative impact. CCD and the possible role of neonicotinoids in such a phenomenon, is a matter of public concern due to exaggerated and inaccurate representations in the media based on scientifically unconfirmed reports of CCD in Europe and the US (Hopwood et al. 2012; Arnason 2015). Much of the extrapolation to CCD for bees has been based on reports about the toxicity to bees of the neonicotinoid pesticides derived in laboratory "swab" tests in which the chemical is applied directly to the body of the bee at concentrations well above expected concentrations after vector control (Bradbury 2013). The label for the neonicotinoid pesticides does, in fact, suggest that all neonicotinoid pesticide products state: "Do not apply this product while bees are foraging. Do not apply this product until flowering is complete and all petals have fallen" as a requirement for the use of these pesticides in regions that contain active bee activity, both agricultural and associated urban hives. These label mandates have been developed to minimize the potential for bee exposures and have been on the labels since 2013 (Bradbury 2013).

USEPA recognizes the value of the neonicotinoid pesticides for agriculture and indicates that care must be taken when using these products. However, it is also clear that the reports in the media of "bee colony collapse syndrome" have not been tied solely to the use of these products (USEPA 2016). Rather, most of the reports of bee colony collapse syndrome have been exaggerated and/or inappropriately connected to pesticide use without considering the effects of loss of habitat, loss of flowering plants and trees due to development, mite infections, viruses, stress due to movement of the colony for agricultural pollination at different locations, and predators to the colony. Identification of the confounding factors associated with the CCD phenomenon has resulted in more care given to reduce the stresses and/or habitat losses that directly adversely impact bee survival and bee colony status. In contrast to some of the nonscientific and personal reports of possible bee deaths and CCD in the press and other media in Canada (Thomson and Ahluwalia 2015) and the US (Brown 2014; UC Master Gardener Program of Sonoma County 2016), according to information from apiary publications, reported cases of CCD have declined substantially in Canada over the last several years (MAAREC 2016). The number of hives that do not survive over the winter months – the overall indicator for bee health – has maintained an average of about 28.7 percent since 2006-2007, but dropped to 23.1 percent for the 2014–2015 winter. While winter losses remain somewhat high, the number of those losses attributed to CCD has dropped from roughly 60 percent of total hives lost in 2008 to 31.1 percent in 2013; and initial reports for 2014-2015 losses also appear to be on the decline.

On a broader scale, the existence or extent of a cumulative impact to pollinators by pesticides in general is unclear. A USEPA report, developed in conjunction with Environment Canada and California Department of Pesticide Regulation (*White Paper*: *In Support of the Proposed Risk Assessment Process*

for Bees, USEPA et al. 2012), found that a definitive linkage of reported bee deaths primarily to pesticides cannot be established. Among the numerous conclusions and recommendations in the White Paper is a statement addressing this complexity:

> There are several challenges that exist when integrating the various exposure and effects data that can be used to assess potential effects of pesticides on honey bees and their colonies. For instance, different bees are expected to be exposed to pesticides at different magnitudes, depending upon their function in the colony. In addition, interpreting the impacts of mortality and sublethal effects on the ultimate survival of the colony is complicated by a lack of definitive understanding of the linkages between many of these endpoints.

A follow on review and critique of the White Paper by a select panel of scientists, both internal to the regulatory agencies and outside (representing universities, other federal agencies and commercial agricultural product companies), emphasized and validated the many questions associated with the linkage of specific pesticide exposure and the other confounding factors in the White Paper.

While pesticide toxicity to bees has been demonstrated and summarized by the USEPA, the toxicity data used in USEPA guidance is generated using bees in the laboratory. This test is conducted by using a pesticide-saturated cotton swab, applied firmly against the thorax, resulting in a contact exposure far greater than would be achieved in actual field conditions (USEPA 2012b; Fishel 2005). In contrast to this purposeful and artificially exaggerated laboratory contact exposure, the toxicity values reported in USEPA guidance are not typical of the more likely casual contact with any pesticide used in District vector control applications, which both due to the levels applied and compliance with BMPs designed to avoid or minimize exposure to pollinators, do not approach these potential exposure levels.

Seasonal impacts on bees and their colonies are common and typical for most areas in North America, where bees are raised commercially or as a hobby (MAAREC 2016). Further complicating the understanding of potential pesticide impacts to bees and other pollinators is the widespread urban use of many of these pesticides by homeowners, gardeners, and others who commonly use these chemicals. Urban use of insecticides can be a large percentage of total use nationally (Aspelin 2003). However, by following the practices that reduce potential exposure as indicated in the label guidelines and USEPA regulatory guidance, safe applications of pesticides can be practiced without substantial adverse effects to bee colonies.

As noted, the District does not use neonicotinoid products; thus, to the extent CCD is an actual impact caused by neonicotinoids, the District's Program does not contribute to this impact. For the products used or potentially used by the District, the District BMPs reflect an understanding of and adherence to guidance designed to minimize effects on bees and include additional recommendations limiting pesticide use only within the wind speed parameters on the product labels conditions. The guidance and the BMP approach is tailored to minimize the potential for direct bee exposure to any of the pesticides used for vector control by the District. Furthermore, the District uses the following BMP H12 for pesticide applications that is contained in Table 2-6 in Section 2.9:

> "Do not apply pesticides that could affect insect pollinators in liquid or spray/fog forms over large areas (more than 0.25 acres) during the day when honeybees are present and active or when other pollinators are active. Preferred applications of these specific pesticides are to occur in areas with little or no honeybee or pollinator activity or after dark. These treatments may be applied over smaller areas (with hand held equipment), but the technician will first inspect the area for the presence of bees and other pollinators. If pollinators are present in substantial numbers, the treatment will be made at an alternative time when these pollinators are inactive or absent."

As with all pesticides, the USEPA provides label guidance and mandates that have been developed to minimize the potential for exposure, and the labels are based on extensive laboratory and field tests of

toxicity to bees that have been directly exposed to these chemicals to determine the worst case scenarios if the bees become directly coated with the pesticide (spraying) and if they are in direct, extended contact with contaminated vegetation. The mandated label restrictions are based on the following supporting information used to minimize the potential for direct exposure (USEPA 2012c):

> USEPA (2012c) registration includes the following:
>
> - Minimize exposure of this product to bees and other insect pollinators when they are foraging on pollinator attractive plants around the application site.
> - Minimize drift of this product on to beehives or to off-site pollinator attractive habitat. Drift of this product onto beehives or off-site to pollinator attractive habitat can result in bee kills. Utilize Best Management Practices that reduce the likelihood of exposure, including application restrictions during potential drift conditions, proximity to known colonies and other information about the status and activity of the bees in the area of proposed applications.

Research reported for bees is also relevant to other pollinators. One way to consider the larger issue of impacts to pollinators (i.e., butterflies and moths in addition to bees) aside from CCD and pesticide use is to consider recent information from bee-keeper journals from Canada that honey production has improved. While agricultural and urban use of pesticides in Canada is similar to that of the US (Agriculture and Agri-Food Canada 2013, Crop Protection Survey), the impact on bees and bee colonies appears to be minor. In Canada, *Statistics Canada* reported that beekeepers produced 95.3 million pounds of honey, up from 85.5 million last year and 76.5 million in 2013. Alberta produced most of the production gain as beekeepers increased production by 7.3 million lb, from 35.5 million in 2014 to 42.8 million in 2015. Beekeepers produced more honey because bee colony numbers jumped 3.6 percent compared to 2014. Prairie bee colonies in 2015 had winter losses averaged 11 percent in Manitoba, Saskatchewan, and Alberta, much lower than losses of 20 to 40 percent in previous years. National honey yields were also up. Beekeepers averaged 132 lb. per hive, a gain of nine lb. over 2014. Because other insect pollinators do not produce honey, there is no similar method for showing increases in these pollinators. However, this information from Canada suggests that pesticide use is not a substantial contributing factor to adverse effects on bees and bee colonies.

Many reports of adverse effects of pesticides to Monarch butterflies and some moths have been provided in the press, with a link to the indirect effect of glyphosate on reduction of the milkweed plant that serves as a food source and provides habitat during foraging and migration. Some of the issues associated with loss of bees and butterflies is outlined in a recent *Science* article (B. Keim 2014) in which the author addresses the loss of flowering plants and environmental changes as likely causes of the perception that these species are in decline. Although the author suggests that some reported declines in bees and butterflies may be due to pesticides, numerous other factors contribute to this impact and he indicates that it is difficult to actually quantify adverse effects. In fact, in addition to the impact of viruses, parasites, and natural stressors, he suggests that pesticide impacts may be eclipsed by habitat loss since pollinator habitat is disappearing nationwide. Most of the reports of pollinator declines ignore the numerous confounding factors that are in play and make unsubstantiated extrapolations to chemical effects regardless of the likely actual exposures.

There is an annual native bee count in Sonoma County that will provide valuable data to researchers at UC Berkeley, who are able to discern information about the health of an ecosystem from the diversity of the bee population. They plan to publish their results in the journal *Conservation Biology*. Preliminary information suggests that native bee species have declined in the last year, which researchers attributed to the drought that has parched the region for two straight summers. (Brown 2014)

Pollinator populations fluctuate over time and are affected by many different contributing factors. Therefore, it is not possible to definitively link use by District (at levels established by the USEPA and according to additional BMPs) to a long-term decline locally. Although the USEPA provides summaries of

the data on potential adverse chemical impacts to bees using direct thoracic exposures in laboratory tests (USEPA 2012b), one current theory about bee deaths has been casually associated with the use of pesticides, including the neonicotinoid pesticides, which the District does not use. Even so, USEPA has stated that it recognizes the value of pesticides for agriculture and its use by homeowners for pest management, and indicates that care (as described previously) must be taken when using these products. However, it is also clear that the reports in the media of "bee colony collapse syndrome" have not been tied solely to the use of any specific pesticide, including any of the District products in use or proposed for use (USEPA 2016*).* BMPs and application label requirements address both bees and other insect pollinators, and are implemented to avoid substantial harm to these insects within the District's Service Area by District activities. Other factors such as drought may be affecting declines in pollinator populations. Measures on the pesticide labels along with additional BMPs ensure the District's activities, including use of chemicals, are not having a significant impact on insect pollinators, nor are they contributing considerably to a cumulative impact considerably to a cumulative impact on insect pollinators. All these reasons support the analysis and conclusion in the Draft PEIR Section 13.3.1, page 13-8, that the Program's less-than-significant impacts on insect pollinators related to mosquito and yellow jacket abatement activities would not be cumulatively considerable or significant.

Also see Responses 7 and 27.

Response 27

The comment argues that urbanization and urban limitations on beekeeping are not having a significant impact on pollinators in the Program Area, that this impact is overstated, therefore the District's contribution to cumulative impacts are understated.

It is important to note that a discussion of cumulative impacts is intended to address all of the components or confounding factors that could be involved. Cumulative impacts may occur when several less-than-significant impacts contribute to an impact that is significant as a result of the aggregation of the incremental impacts. Urbanization most often results in a reduction in agricultural land, and agricultural land provides foraging opportunities for pollinators, especially for crops where flowering precedes the production of fruit such as vineyards and orchards. Limitations on beekeeping in urban areas would further contribute to a decline in pollinator populations. The issue is not whether urbanization itself has a significant impact on pollinator populations but whether it has any impact, even a less-than-significant one that may be contributing to a cumulative impact. That beekeeping is allowed in some residential areas in addition to the more extensive beekeeping activities associated with agricultural uses is a part of the issue but it does not cause an understatement of the District's potential contribution to cumulative impacts to pollinators. The PEIR provides an overview of the beekeeping industry and defines the wider range of bee activity and the possible source of bee exposures beyond the areas where the District applies chemicals for vector control. Although there have been numerous media reports that bees and bee colonies are being adversely impacted by pesticides, the available data suggests that any reported reduction in bee numbers or bee colonies are highly exaggerated and likely focused on the wrong sources of stress and exposure. Where reductions in bee numbers have been reported, one of the claims is pesticide poisoning. However, there are numerous reports suggesting and supporting the likely relationship of adverse environmental factors, disease, parasites, and unusual predation, as probable causes of the reduction of numbers of bees.

The foraging range of bees in pursuit of nectar is fairly closely tied to the location of the hives, including the artificial hives used for collection and sale of honey. Although there is some indication that bees may forage as far as several miles from the hive, a practical maximum distance from the hive has been summarized for several reports (Traynor 2002 and several other reports), and is said to be a maximum of approximately 3 to 4 miles when nectar is not readily available closer to the hive. The PEIR addresses the larger issue of urban development and loss of agricultural lands that had beekeeping associated with

them to promote the fertilization of the numerous crops that depend on bees for fertilization. Loss of some agricultural land is also loss of habitat for bees and other insect pollinators.

As discussed above, most of the reports of bee colony collapse syndrome have been exaggerated and/or inappropriately connected to pesticide use without considering the effects of loss of habitat, loss of flowering plants and trees due to urban development, mite infections, viruses, stress due to movement of the colony for agricultural pollination at different locations, and predators to the colony. Identification of the confounding factors associated with the CCD phenomenon has resulted in more care given to reduce the stresses and/or habitat losses that directly adversely impact bee survival and bee colony status. In many cases, loss of honey productivity is not actually associated with decreased bee activity or the loss of bee numbers or the Colony Collapse Disorder reported by the media. In fact, one of the current impacts of lower honey productivity can be attributed to theft of thousands of beehives and displacement of the appropriate hive locations.

For additional information on bee population decline and other pollinators, see Responses 26 and 28.

Response 28

Adverse impacts to other non-bee pollinators and food web predator populations have not been reported as a result of focused applications of vector control pesticides. In fact, pollinator populations fluctuate over time and are affected by many different contributing factors. It is not possible to definitively link use of vector control products by the District (at levels established by the USEPA and according to additional BMPs) to a long-term decline or one that would adversely impact the predator population of interest. It is well known in population biology that every population can adequately respond and recover to a loss of large percentages of individuals based on their intrinsic reproductive vigor. Populations with very short reproductive gestation periods (most insects and some small mammals) will recover much faster than populations with long reproductive cycles (large mammals and some birds). In fact, there are many theories about how many individuals in a population can be lost before the likelihood of significant impact or extinction may occur.

References to some of the predators of mosquitoes can be found dating back more than 100 years and help form the basis for much of the research that has occurred since (Beutenmuller 1890; Felt 1904; Howard 1901, 1910: Mitchell 1907; Smith 1904; Underwood 1903; Weeks 1890). These selected publications (provided as an example among dozens of others) have not established a defensible concept of adverse impacts from localized mosquito control to predators and other related populations. Other factors such as drought may be affecting declines in pollinator populations. District BMPs and application label requirements address both bees and other insect pollinators, and are implemented to avoid substantial harm to these insects within the District's Service Area by District activities. Because of the selective nature of the vector control products for mosquitoes, any claimed potential adverse impact to insect predators (as nontarget exposures) associated with District applications would be temporary and inconsequential in the impact to those populations of predator species. Even in the event of ancillary exposures, the recovery of such populations occurs rapidly to maintain the general level of individuals in their populations. The relative higher sensitivity of the target vs nontarget (less sensitive predator) species provides an adequate measure of safety to maintain the balance of predator populations. As discussed in the PEIR and other responses to this commenter's comments, based on the available evidence it is reasonable to assume that District pesticide applications under the Program, using required limitations in application methods and rates as found on the product labels and in District BMPs, will not result in a significant impact to these populations or higher trophic level species that consume mosquitoes as part of their diet.

Also see Response 12.

Response 29

Potential water quality impacts to groundwater and surface water from application of vector control chemicals are analyzed in Sections 9.2.5 and 9.2.7 of the PEIR, the Vegetation Management and Chemical Control alternatives, respectively. Each of the active ingredients and adjuvants applied by the District were evaluated individually with consideration of pesticide's mode of action, persistence in the environment, toxicity, and environmental fate. Furthermore, the District's methods for application of the material, such as ULV techniques, were also considered. Based on this evidence and expert analysis, the Draft PEIR concludes that the vector control chemicals would have less-than-significant impacts to surface water and groundwater when applied consistent with the vector control application techniques, label requirements, and BMPs implemented by the District.

With respect to the cumulative impact assessment, the PEIR focuses on the actual effects the District's contribution will have on the environment at the cumulative level. Contrary to what is implied by the commenter, *Communities for a Better Environment v. California Resource Agency* (103 Cal. App 4th 98) does not require that the District find that any level of contribution to an existing cumulative impact be deemed cumulatively considerable, particularly when program and/or project effects are indirect or uncertain. As discussed in Section 13.7 of the PEIR, several studies have shown that specific vector control chemicals applied using ULV techniques do not accumulate in water or sediment following repeated applications. These studies have also determined that no toxicity is associated when exposure is limited to the amounts used when following ULV protocols for mosquito control (Lawler et al. 2008; Amweg et al. 2006). Furthermore, the monitoring of pesticides used for vector control on waters throughout California has not detected impacts to beneficial uses, as described in Response 23 above. A two-year monitoring study conducted for the State Water Resources Control Board by the Mosquito and Vector Control Association of California (MVCAC) monitoring coalition to determine whether vector control activities were contributing contaminants to state waters supports the PEIR's conclusions that impacts to water quality from the District's IVMP are less than significant and that the District's use of vector control chemicals would not contribute considerably to an existing cumulative impact (from all other pesticide users' activities) to water quality in the Program Area and thus are not cumulatively considerable. (MVCAC 2013)

Also see Response 23.

Response 30

As discussed in Responses 25 through 29, the cumulative impact analysis is not deficient, and recirculation of the Draft EIR is not required. Material provided in these responses to comments provides sufficient clarification to be clear on points raised, and this material will be made public as part of the Final PEIR.

Response 31

The PEIR does not gloss over program EIR requirements, nor does it presumptively dismiss the need for future CEQA evaluation. Rather, Section 1.8, Use of This PEIR for Future CEQA Compliance (pages 1-22 through 1-27) clearly acknowledges that the analysis is limited to the activities and materials that can be identified at present. It notes that "Future activities not within the scope of the Program evaluated in the PEIR are considered "new actions" and may be subject to future environmental review under CEQA" (Section 1.8.1, page 1-23). It also clearly outlines the steps that would be followed in determining whether additional CEQA analysis would be required in the future. The specific process the District will follow to ensure CEQA compliance as it moves forward implementing its Program is explained in greater detail in Sections 1.8.1 and 1.8.2. The comment seems to suggest that the District make a determination now whether future activities would be subject to additional CEQA, but this is not feasible because they are not known. The CEQA Guidelines § 15144 notes that foreseeing the unforeseeable is not possible, but that an

agency must use its best efforts to find out and disclose all that it reasonably can. This PEIR has done that, describing for example all pesticides in current use and a number of pesticides not currently in use but with the potential for use in the foreseeable future (Section 1.8.1.1, page 1-23). The CEQA Guidelines § 15145 do not require speculation, however, and the EIR has outlined the steps that would be taken to ensure compliance with CEQA in the future for both chemical and nonchemical treatments. One of the purposes of this PEIR has been to anticipate reasonably foreseeable vector control activities by the District in order to avoid use of the emergency action exemption provisions if there were a serious outbreak of vector-borne disease requiring immediate action, thus ensuring that, to the extent feasible, potential impacts have been evaluated and disclosed to the public and decision makers in advance of any action.

Response 32

Comment noted that the Draft BDCP is out of date. According to The Resources Agency website, information on the Bay Delta Conservation Plan (BDCP) and the supporting environmental review process can now be found at http://baydeltaconservationplan.com/. The discussions of the Bay Delta Conservation Plan have been deleted from Sections 4.1.4.5, 5.1.4.5 and Table 4-5 because, as the comment notes, this is no longer an HCP/NCCP. This plan's removal from these sections has no effect on the conclusions of the impact analyses or on the alternatives or mitigation measures that were developed. Therefore, this text change is not substantial and does not require recirculation of the Draft PEIR.

Response 33

The only time Wikipedia was cited was in the Land Use environmental setting Section 3.1.2 Public Lands, where it was used as a source of information for the number of square miles in Sonoma County and acreages in the San Pablo Bay National Wildlife Refuge. This is not substantive information for the impact analyses and has no bearing on the conclusions of the impact analysis. Most of the acreage information in the environmental setting was obtained from Marin County and Sonoma County.

Response 34

The correct links have been provided in the text changes section of this Final PEIR. All of the documents were obtained/downloaded when the PEIR was prepared, and these materials were available upon request during public review of the PEIR. Website links are provided for ease of reference but do change over time.

Below find current links as of May 24, 2016:1. http://www.baaqmd.gov/~/media/files/planning-and-research/ceqa/revised-draft-ceqa-thresholds-justification-report-oct-2009.pdf?la=en

> http://baydeltaconservationplan.com/Library/BDCPLibrary/WhatistheBDCP.aspx

> http://www.ceden. .waterboards.ca.gov/AdvancedQueryTool

> http://ci.corte-madera.ca.us/182/General-Plan

> http://www.ci.healdsburg.ca.us/354/General-Plan

> https://www.climate.gov/maps-data/dataset/average-wind-speeds-map-viewer

> http://sonomacounty.ca.gov/TPW/Air-Quality-Northern-Sonoma-County

> http://www.townofross.org/planning/page/climate-action-plan

> http://www.townofross.org/planning/page/general-plan

> http://www.townofsananselmo.org/DocumentCenter/Home/View/553

> http://www.townofsananselmo.org/index.aspx?nid=216

> http://www.co.solano.ca.us/depts/rm/planning /generalplan.asp

> http://www.scwa2.com/water-supply/habitat/solano-multispecies-habitat-conservation-plan

> http://www.sonoma-county.org/prmd/gp2020/osrce.pdf *and* http://www.sonoma-county.org/prmd/gp2020/wre.pdf

> http://www.sonoma-county.org/prmd/gp2020/lue.pdf

> http://sonomacounty.ca.gov/CAO/Public-Reports/About-Sonoma-County/Land-Use/

> https://www2.municode.com/library/ca/sonoma_county/codes/code_of_ordinances?nodeId=CH7BURE#!

> http://www.townoftiburon.org/206/General-Plan

> http://newscience.ul.com/wp-content/uploads/2014/04/Indoor_Air_Pollution_an_Overview.pdf

> https://www3.epa.gov/nonroad/documents/21a2001.pdf

> https://www3.epa.gov/ttn/emc/facts.html

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> WHO 1989 is a book, the PDF of which is no longer available free of charge online.

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Attachment A – Literature Review

Evaluations of many of the studies cited in (or consulted for) the responses to public comments for the District's Final PEIR are provided below.

Adams MJ, Miller DAW, Muths E, Corn PS, Grant EHC, Bailey LL, et al. 2013. Trends in Amphibian Occupancy in the United States. *PLoS ONE* 8(5).

> These authors conducted an analysis of the rate of change in the probability that amphibians occupy ponds and other comparable habitat features across the United States. They report that overall occupancy by amphibians declined 3.7% annually from 2002 to 2011. Species that are of concern are said to have declined an average of 11.6% annually. Their computer modeling approach is used to suggest that amphibian declines may be more widespread and severe than previously realized. However, this report is based on extrapolation of probability to reach their conclusions.

Antunes-Kenyon, S. and G. Kennedy. 2001. Methoprene: A review of the impacts of the insect growth regulator methoprene on non-target aquatic organisms in fish bearing waters (Ver. 2.0). Prepared for Massachusetts Pesticide Board Subcommittee. August.

> Address limb regeneration and molting ability of a crustacean indicator species, Uca pugnax. A runoff event simulation with permethrin contaminated sediment found that U. pugnax experienced induction of hepatopancreas glutathione S-transferase activity while respiration and hemolymph osmolarity did not vary. This detoxification enzyme a generalist biomarker. Claims that chronic methoprene exposure at environmental concentrations caused increased male abnormal regenerative limbs and delays in proecdysis. Both male and female crabs displayed increased variability in water-soluble exoskeleton protein possibly affecting exoskeleton quality. In addition, males displayed methoprene and permethrin non-additive effects on total exoskeleton protein content, reduced body mass gain, reduced carapace width gain and overall body condition loss. Females displayed resilience by only experiencing reduced carapace size gain and increased respiration rate, possibly due to increased metabolic and biotransformation of both pesticides. Claims that inputs of insect growth regulators, pyrethroid insecticides or their mixture into coastal wetland environments pose a risk to crustacean physiology, fitness and sensitive growth processes.

Arnason, Robert. 2015. Beekeepers produce bumper honey crops. Statistics Canada. December. As also reported in *The Western Producer Bee Keeper Journal*.

> Bee keeper journal article intended for the use of commercial and other bee keepers about the status of honey production, possible bee impacts of pesticides and other factors.

Aspelin, A.L. Pesticide usage in the United States: Trends During the 20th Century. *CIPM Technical Bulletin* 105. February.

> Reports on the urban vector control applications, indicating that there are numerous sources of pesticides found in urban creeks including structural uses, ant control applications, and homeowner applications to lawns.

Barberis, C.L., C.S. Carranza, S.M. Chiacchiera, and C.E. Magnoli. 2013. Influence of herbicide glyphosate on growth and aflatoxin B1 production by Aspergillus section Flavi strains isolated from soil on in vitro assay. *Journal of Environmental Science and Health*, Part B, 48(12), 1070-1079. (on toxic fungi appearing in soil sprayed with glyphosate).

> These authors report on the effect of six glyphosate concentrations on growth rate and aflatoxin B1 (AFB1) production by Aspergillus section Flavi strains under different water activity (aW) on maize-based medium. In general, the lag phase decreased as glyphosate concentration

increased and all the strains showed the same behavior at the different conditions tested. They suggest that at high concentrations glyphosate significantly increased the growth of all Aspergillus section Flavi strains. Aflatoxin B1 production did not show noticeable differences among different pesticide concentrations assayed at all aW in both strains. This study has shown that these Aspergillus flavus and A. parasiticus strains are able to grow effectively and produce aflatoxins in high nutrient status media over a range of glyphosate concentrations under different water activity conditions.

Bradbury, Steven, Director OPP. 2013. Transmission letter from Fred Jenkins (FIFRA) on Pollinator Protection Labeling for Nitroquanidine Neonicotinoid Products. USEPA letter to registrants, August 15, 2013.

> Letter available from the USEPA head of Pesticides Programs to be aware of the potential for new restrictions about the use and availability of existing pesticides with neonicotinoid properties and the requirement to include new tests in the registration process.

Brodman, R., W.D. Newman, K. Laurie, S. Osterfeld, and N. Lenzo 2010. Interaction of an aquatic herbicide and predatory salamander density on wetland communities. *Journal of Herpetology* 44(1):69-82.

> Report suggesting that pesticides could have unintended impacts on amphibians These authors conducted a replicated field experiment in constructed ponds to test for both the effects of Accord and predator (Tiger Salamanders, *Ambystoma tigrinum*) density on amphibians and aquatic invertebrates. Herbicide treatment had significant density-dependent effects on Tiger Salamander growth, development, and survival. The survival of anurans and aquatic invertebrates was also affected by herbicide treatment and predator density. These results suggest that competition and predation may mediate indirect effects of this herbicide on the aquatic fauna. They conclude that exposure to Accord poses less of a risk to the ecology of amphibians than do other formulations of glyphosate-based herbicides.

Brown, Matt. 2014. Drought may be taking toll on bees in Sonoma. *The Press Democrat*, June 28. Available online at http://www.pressdemocrat.com/csp/mediapool/sites/PressDemocrat/News/story.csp?cid=237153 2&sid=555&fid=181.

> Publication in the newspaper (online) Press Democrat of Sonoma suggesting that the perceived loss of bees in the county and elsewhere may be related to the extreme drought conditions in California and particularly in the Sonoma area. The article was based on information in the UC Davis publication series on bees and agriculture. This is a hypothetical comment that is focused on the loss of bees reported associated with drought conditions in the agricultural communities of California.

California Department of Pesticide Regulation (CDPR) 1995. California State Plan for Protection of Endangered Species from Pesticide Exposure. September 13.

> The purpose of this plan is to protect federally listed endangered species in California from potentially harmful pesticide exposures, incorporating federal protection strategies or developing alternative local plans where needed. This Plan includes all federally listed species designated threatened, endangered, proposed threatened, proposed endangered and Category 1 candidate species in California and will address new listings on an ongoing basis. This plan includes all federally listed species designated threatened, endangered, proposed threatened, proposed endangered and other candidate species in California. This plan includes all pesticides registered for use in California and all types of registrations including new active ingredients, experimental use permits and emergency exemptions.

Canadian Council of Ministers of the Environment. 2007. Canadian Water Quality Guidelines for the Protection of Aquatic Life. Methoprene. Available online at http://ceqg-rcqe.ccme.ca/download/en/192.

> Listing of Methoprene target levels for risk… 0.09 target organism, and 0.53 management value.

Csondes, A. 2004. Environmental Fate of Methoprene. 6 pp whitepaper prepared by CDPR. Available online at http://www.cdpr.ca.gov/docs/emon/pubs/methofate.pdf.

> **Review of methoprene characteristics, physiochemical etc., includes tables of toxicity and properties.** Methoprene disrupts the insects' metamorphosis and life cycle, thus hindering their ability to reach adulthood and successful reproduction. Special slow-release formulations are commonly used for mosquito control, especially breeding in floodwater sites, rice cultivations, storm drains, ponds, and water treatment works.

Davis, R.S., R.K.D. Peterson, and P.A. Macedo. 2007. An Ecological Risk Assessment for Insecticides used in adult mosquito management. *Integrated Environmental Assessment and Management* 3 (3): 373–382.

> This author developed a deterministic ecological risk assessment focused on 6 common mosquito adulticides used in vector control, including 3 pyrethroids (dphenothrin, resmethrin, and permethrin), pyrethrins, and 2 organophosphates (malathion and naled). Piperonyl butoxide, a synergist for the pyrethroids, was also assessed. Both aquatic and terrestrial nontarget organisms were considered for acute and chronic exposures to the adulticides. Tier I exposure estimates were derived from ISCST3 and AERMOD for deposition and air concentrations affecting terrestrial organisms and PRZM-EXAMS for standard pond concentrations affecting aquatic organisms. Nontargets exposed to adulticides included small mammals, birds, as well as aquatic vertebrates and invertebrates in a pond subject to receiving the chemical via drift and runoff. Risk quotients were obtained by comparing exposures to toxic endpoints. All risk quotients were low indicating that risks to ecological receptors most likely were small.

Davis, R.S. and R.K.D. Peterson. 2008. Effects of single and multiple applications of mosquito insecticides on nontarget arthropods. *Journal of the American Mosquito Control Association* 24(2):270-280.

> These authors conducted two studies during the late summers of 2004 through 2006 at Benton Lake National Wildlife Refuge near Great Falls, MT. in 2004 and 2005 to assess acute impacts of mosquito adulticides (permethrin and d-phenothrin) and larvicides (Bacillus thuringiensis israelensis and methoprene) on nontarget aquatic and terrestrial arthropods after a single application. The second experiment was conducted in 2005 and 2006 to assess longer-term impacts of permethrin on nontarget terrestrial arthropods after multiple repeated applications. For aquatic samples, in the first study, no overall treatment effects were observed. Three response variables were associated with fewer individuals present in the insecticide-treated plots in a multivariate analysis. For the multiple-spray study conducted in 2005 and 2006, six of the response variables collected via sticky cards exhibited significant overall treatment effects, but none was associated with fewer individuals in the insecticide-treated plots. None of the responses collected using sweep-net sampling suggested overall treatment effects. No discernable pattern was evident. In general, nearly all of the responses evaluated indicated few, if any, deleterious effects from insecticide application.

Degitz, S.J., E.J. Durhan, J.E. Tietze, P.A. Kosian, G.W. Holcombe, and G.T. Ankley. 2003. Developmental toxicity of methoprene and several degradation products in *Xenopus laevis. Aquatic Toxicol.* June; 64 (1):97-105.

> Methoprene is an insect juvenile growth hormone mimic, which inhibits pupation and is used for the control of emergent insect pests such as mosquitoes. Some claims that methoprene use in US may be a contributing factor to the recent increase in malformed amphibians. However, little is known concerning the developmental toxicity of methoprene and its degradation products in amphibians. In these studies, the aqueous stability and developmental toxicity of methoprene and several degradation products (methoprene acid, methoprene epoxide, 7-methoxycitronellal, and 7-methoxycitronellic acid) were examined. Xenopus laevis embryos (stage 8) were exposed to the test chemicals for 96 h. Assays were conducted under static renewal (24 h) conditions and chemical concentrations in water were measured at the beginning and end of the renewal periods. **Methoprene exposure did not result in developmental toxicity at concentrations up to 2 mg/l, which is slightly higher than its water solubility**. Methoprene acid, a relatively minor degradation product, produced developmental toxicity when concentrations exceeded 1.25 mg/l. Methoprene epoxide and 7-methoxycitronellal caused developmental toxicity at concentrations of 2.5 mg/l and higher. 7-Methoxycitronellic acid was not developmentally toxic at a test concentration as high as 30 mg/l. The five test chemicals had differential stability in aqueous solution that was in some instances affected by the presence of test organisms. These data indicate that **methoprene and its degradation products are not potent development toxicants in X. laevis.** This, in combination with the fact that field applications of sustained-release formulations of methoprene result in methoprene concentrations that do not typically exceed 0.01 mg/l, suggests that **concerns for methoprene-mediated developmental toxicity to amphibians may be unwarranted.**

de María, N., J.M. Becerril, J.I. García-Plazaola, A. Hernandez, M.R. De Felipe, and M. Fernandez-Pascual. 2006. New insights on glyphosate mode of action in nodular metabolism: Role of shikimate accumulation. J. Agric Food Chem. April 5;54(7):2621-8.

> These authors tested the short-term effects of glyphosate on the growth, nitrogen fixation, carbohydrate metabolism, and shikimate pathway in leaves and nodules of nodulated lupine plants. All glyphosate treatments decreased nitrogenase activity rapidly (24 h) after application, even at the lowest and sublethal dose used (1.25 mM). This early effect on nitrogenase could not be related to either damage to nitrogenase components (I and II) or limitation of carbohydrates supplied by the host plant. These effects were accompanied by inhibition of the activity of phosphoenolpyruvate carboxylase (PEPC). There were rapid effects on the increase of shikimic and protocatechuic (PCA) acids in nodules and leaves after herbicide application. On the basis of the role of shikimic acid and PCA in the regulation of PEPC, as potent competitive inhibitors, this additional effect provoked by glyphosate on 5-enolpyruvylshikimic-3-phosphate synthase enzyme (EPSPS; EC 2.5.1.19) inhibition would divert most PEP into the shikimate pathway, depriving energy substrates to bacteroids to maintain nitrogen fixation. They suggest that these findings provide a new explanation for the effectiveness of glyphosate as an herbicide in other plant tissues, for the observed differences in tolerance among species or cultivars, and for the transitory effects on glyphosate-resistant transgenic crops under several environmental conditions.

De Roos, A.J., A. Blair, J.A. Rusiecki, J.A. Hoppin, M. Svec, M. Dosemeci, D.P. Sanler, and M.C. Alavania. cancer incidence among glyphosate-exposed pesticide applicators in the Agricultural Health Study, *Environmental Health Perspectives* Jan;113 (1).

> These authors evaluated associations between glyphosate exposure and cancer incidence in the Agricultural Health Study (AHS), a prospective cohort study of 57,311 licensed pesticide applicators in Iowa and North Carolina. Detailed information on pesticide use and other factors was obtained from a self-administered questionnaire completed at time of enrollment (1993–1997). Among private and commercial applicators, 75.5% reported having ever used glyphosate, of which > 97% were men. In this analysis, glyphosate exposure was defined as a) ever personally mixed or applied products containing glyphosate; b) cumulative lifetime days of use, or "cumulative exposure days" (years of use × days/year); and c) intensity-weighted cumulative exposure days (years of use × days/year × estimated intensity level). Poisson regression was used to estimate exposure–response relations between glyphosate and incidence of all cancers combined and 12 relatively common cancer subtypes. Glyphosate exposure was not associated with cancer incidence overall or with most of the cancer subtypes we studied. There was a suggested association with multiple myeloma incidence that should be followed up as more cases occur in the AHS.

Extension Toxicology Network (EXTOXNET). 1995. Pesticide Information Profile. Methoprene. Available online at http://pmep.cce.cornell.edu/profiles/extoxnet/haloxyfop-methylparathion/methoprene-ext.html.

> Information and suggested toxicity data used to determine the potential toxicology issues to outline the possible impacts of these pesticides on several species.

Fishel, F.M. 2005. Pesticide toxicity profile: neonicotinoid pesticides. UF/IFAS EDIS Document PI-80. Available online at http://edis.ifas.ufl.edu/pi087.

> This document provides an excellent, comprehensive and general overview of human toxicity, a listing of laboratory animal and wildlife toxicities, and a cross-reference of chemical, common, and trade names of many neonicotinoid pesticides registered for use in Florida. Along with the toxicity information of LD50, LC50 and dermal toxicity for five common neonicotinoids, he addesses humans and wildlife, the author has a section directed specifically to the issue of toxicity to bees and the perceptions of bee colonly collapse disorder (CCD). This document is PI-80, one of a series of the Pesticide Information Office, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida.

Henrick, C.A., J. Ko, J. Nguyen, J. Burleson, G. Lindahl, D. Van Gundy, and J.M. Edge. 2002. Investigation of the relationship between s-methoprene and deformities in anurans. 2002. *Journal of the American Mosquito Control Association* 18(3):214-221

> Reports on their acute toxicity tests that incorporated direct applications of methoprene to jugs of pondwater that resulted in unrealistic exposures when the test species was introduced to the jugs as the test medium. Reported that methoprene is toxic to amphibians, such as frogs, toads, and salamanders but at relatively high exposure concentrations. A comparison of reported Altosid use with reported frog deformities in Minnesota demonstrate that a connection between frog deformities and Altosid use is unlikely". These results indicated that factors other than s-methoprene and its degradation products are contributing to the recent outbreak of frog deformities. Their acute toxicity tests that incorporated direct applications of methoprene to jugs of pondwater resulted in unrealistic exposures when the test species was introduced to the jugs as the test medium. These authors report that methoprene is toxic to amphibians, such as frogs, toads, and salamanders but at relatively high exposure concentrations

Hershey, A.E, A.R. Lima, G.J. Niemi, and R.R. Regal. 1997. Bti and methoprene nontarget risks. An 8-year study in Minnesota wetlands. *Ecological Applications* 8 (1) 41-60.

> These authors presented the results of their studies that began in1997 (*Ecological Applications: Vol. 8, No. 1, pp. 41–60*) at the 2002 conference of the MAMCA where they reported the results of the effects of the mosquito larvicides methoprene and Bacillus thuringiensis israelensis (Bti) on the benthic macroinvertebrate communities of 27 wetland ecosystems in Wright County, Minnesota. These larvicides are generally considered safe for nontarget species. After 3 yr of preliminary investigations, including 2 yr of intensive sampling, larvicide treatments were applied during 1991–1993. Nine of the wetlands were experimentally treated with methoprene and an additional set of nine wetlands were treated with Bti. While nine wetlands were left untreated to serve as a control treatment. In general, insecticide treatment had minimal effects on nontarget groups during the first treatment year. They report that in 1992 highly significant reductions due to both methoprene and Bti were observed in several insect groups. Predatory insects were reduced on methoprene-treated sites but not Bti-treated sites in 1992. Effects were observed broadly across insect taxa, Diptera, were affected most strongly, especially the dipteran suborder Nematocera, which included Chironomidae. Minimal effects on non insect macroinvertebrates were observed. Bti- and methoprene-treated sites also showed a reduction in richness of insect genera and an increased tendency to be dominated by one or a few genera.

> These authors suggest that both indirect effects and direct toxicity likely contributed to the observed differences in the target and nontarget species. Bti is likely to be directly toxic only to nematoceran Diptera; thus effects of Bti on other insect groups may have resulted from disruption of the invertebrate food web. Methoprene is more broadly toxic; thus observed methoprene effects on non nematoceran groups may have been due to either direct toxicity or food web effects, or both. They suggest that the observed 2–3 yr lag time in response of nontarget insects to larvicide treatment may require longer term studies to evaluate the safety of these larvicides.

Hopwood, J,M. Vaughn, M. Shepherd, D. Biiddinger, E. Mader, S.H. Black, and C. Mazzacano. 2012. Are neonicotinoids killing bees. A review of research into the effects of neonicotinoid insecticides on bees, with recommendations for action. Xerces Society for Invertrebrate Conservation.Hopwood,

> A Xerces Society report on the condition and status of bees and bee colonies suggesting a connection of pesticides (especially neonicotinoids) to reductions in bee populations. They report that this class of pesticides can persist in soil for months after single application. They also suggest that residues can be found in pollen and nectar which are then consumer flower visiting insects such as bees in some situations concentrations of residues can reach me the levels if consumption is very high. They suggest that imidacloprid, clothianidin, dinotefuran and thiamethoxam are highly toxic to honey bees while thiacloprid and acetamiprid are only mildly toxic to bees. The report focuses on the numerous factora that can impact the potential toxicity of neonicotinoids to bees and other pollinators with suggestions on how to minimize the potential for adverse effects. The authors suggest that Colony Collapse Disorder (CCD) may involve pesticides, but do not provide direct causal evidence in this report.

Johansson. M., H. Piha, and K.H. Merila. 2006. Toxicity of six pesticides to common frog (*Rana temporaria*) tadpoles. *Environ Toxicol Chem*. Dec;25(12):3164-70.

> These authors tested the toxicity of six commonly used pesticides on Rana temporaria spawn and tadpoles. In acute tests, tadpoles were exposed to relatively high concentrations of azoxystrobin, cyanazine, esfenvalerate, MCPA ([4-chloro-2-methylphenoxy] acetic acid), permethrin, and pirimicarb for 72 h. Chronic exposure tests were performed from fertilization to metamorphosis with azoxystrobin, cyanazine, and permethrin at concentrations similar to those

found in surface waters in agricultural areas in Sweden. The most lethal pesticides in these tests of acute exposure were azoxystrobin, permethrin, and pirimicarb. They report negative effects at high doses on the growth of the tadpoles were observed with azoxystrobin, cyanazine, and permethrin. The chronic exposure at lower pesticide concentrations did not result in increased mortality or impaired growth. However, they report a positive effect of permethrin on growth and size at metamorphosis. The results suggest that the pesticides in these tests can inflict strong negative effects at high concentrations but have no or relatively weak effects on R. temporaria spawn or tadpoles at the low concentrations found in Swedish surface waters.

Kiesecker, J.K., A.R. Blaustein, and L.K. Belden 2001. Complex causes of amphibian population declines. *Nature* April 5; 410: 681-684.

> Amphibian populations have suffered widespread declines and extinctions in recent decades. These authors suggest that pathogen outbreaks in amphibian populations in the western USA are linked to climate-induced changes in UV-B exposure. Using long-term observational data and a field experiment, we examine patterns among interannual variability in precipitation, UV-B exposure and infection by a pathogenic oomycete, Saprolegnia ferax. They indicate that climate-induced reductions in water depth at oviposition sites may have caused high mortality of embryos by increasing their exposure to UV-B radiation and, consequently, their vulnerability to infection They further suggest that factors such as precipitation, and thus water depth/UV-B exposure, elevated sea-surface temperatures could be the precursor for pathogen-mediated amphibian declines in many regions.

Lawler, S.P. and D. Dritz. 2013. Efficacy of spinosad in control of larval *Culex tar*salis and chironomid midges, and its nontarget effects. *Journal of the American Mosquito Control Association* 29(4):352-357.

> These authors reported that spinosad is an effective treatment for insect larvae but that it also "kills mayflies and other non-target insects". They also reported that spinosad was effective against mosquitoes and midges for about a month and that spinosad caused mortality of mayflies and other nontarget insects. However, inspection of the results reported in this study indicate that spinosad was considerably less toxic to mayflies than to desired targets, and the minimal effects on mayflies were undetectable after 21 days

Lawler, S.P., D. Dritz, and T. Jensen. 2000. Effects of sustained release methoprene and a combined formulation of liquid methoprene and *Bacillus thuringiensis israelensis* on insects in salt marshes. *Arch. Environ. Contam. Toxicol.* 39:177-182.

> Such deliberate consequences have been possible by the discovery and use of Juvenile Hormone Analogs (JHAs), the synthetic chemicals that mimic JH action, which have also been utilized as insecticides for several decades. Although there is limited use of JHAs for insect pest control, the list of new insect species susceptible to these compounds has been expanding revealing the potential for future use of this class of insecticides. **The relatively fewer effects of JHAs on non-target insects and animals and favorable environmental fate of these compounds make them attractive insecticides.**

Mid-Atlantic Apiculture Research Report (MAAREC). 2005. Seasonal Cycles of Activities in Colonies. Available online at https://agdev.anr.udel.edu/maarec/honey-bee-biology/seasonal-cycles-of-activities-in-colonies.

> This is the publication of the MAAREC established with representation from the departments of agriculture, state beekeeping organizations, and land-grant universities from each of the following states: New Jersey, Maryland, Delaware, Pennsylvania West Virginia, and Virginia. Also participating in the task force is a representative of the USDA/ARS (Beltsville Bee Lab, MD). to identify research and extension priorities for apiculture in the Mid-Atlantic Region, review

proposals, monitor progress, and assist specialists in obtaining funding for apiculture extension and research efforts. The focus of MAAREC research has been on the identification of alternatives to chemical controls and promotion of less reliance on chemical pesticides for mite control. Some of the research objectives consider apiary inspector and beekeeper input and the use of tools such as beekeeper surveys to identify the most effective ways to assist beekeepers in understanding and making sound management decisions for mite and disease control.

McKenney, C.L. 2005. The Influence of insect juvenile hormone agonists on metamorphosis and reproduction in estuarine crustaceans. *Integr. Comp. Biol.* 45:97-105.

> Comparative developmental and reproductive studies on several species of estuarine crustaceans in response to three juvenile hormone agonists (pyriproxyfen, **methoprene** and fenoxycarb). Claims that l**arval development of the grass shrimp**, Palaemonetes pugio, was greater than two orders of magnitude more sensitive to disruption by methoprene and fenoxycarb than was embryonic development. Developing larvae of the mud crab, Rhithropanopeus harrisii, exhibited reduced metamorphic success at lower concentrations of methoprene and pyriproxyfen than grass shrimp larvae. The final crab larval stage, the megalopa, was more sensitive to methoprene and fenoxycarb exposure than earlier zoeal stages. Juvenile mysids released by exposed adults and reared through maturation without further exposure produced fewer young and had altered sex ratios (lower percentages of males) at lower parental-exposure concentrations than directly affected parental reproduction. These findings support using a functional approach as an appropriate screening procedure to evaluate **potential environmental endocrine-disrupting chemicals in aquatic environments.**

McNear Jr., D.H. 2013. The Rhizosphere - Roots, Soil and Everything In Between. Nature Education Knowledge 4(3):1 (at the discussion of "Plant Growth Promoting Rhizobacteria (PGPR)"). Available online at http://www.nature.com/scitable/knowledge/library/the-rhizosphere-roots-soil-and-67500617 [accessed October 1, 2015].

> This monograph report is a compendium of the workings and processes involved in the root system of plants. It provides a good overview of the root system components that may be impacted by chemicals but it does not provide any of the potential sites that would be sensitive to toxicity based on chemical mode of action.

Miles M. and R. Dutton. 2000. Spinosad—a naturally derived insect control agent with potential for use in glasshouse integrated pest management systems. *Meded. Fac. Landbouwkd. Toegepaste Biol. Wet. (Univ. Gent)* 65 (2A):393–400.

> Demonstrated the efficacy of spinosad and the lack of apparent significant impact on other aquatic organisms in their tests

Mink, P.J., J.S. Mandel, B.D. Sceurman, and J.I. Lundin. 2012. Epidemiologic studies of glyphosate and cancer: a review. *Regul Toxicol Pharmacol* Aug;63 (3): 440-452.

> These authors examined the potential risk of glyphosate in humans including a review of the epidemiologic literature to evaluate whether exposure to glyphosate is associated causally with cancer risk in humans. They also reviewed relevant methodological and biomonitoring studies of glyphosate. Seven cohort studies and 14 case-control studies examined the association between life estate and one or more cancer outcomes. Their review found no consistent pattern of positive associations including a causal relationship between total cancer in adults or children or any site-specific cancer and exposure to glyphosate. They further suggest that biomonitoring studies support the importance of exposure assessment and epidemiological studies and indicate that study should incorporate not only duration and frequency of pesticide use but also type of pesticide formulation. They suggest that generic exposure assessments usually lead to

exposure misclassification and recommend that exposure algorithms be validated with biomonitoring data.

Miyakawa, H., K. Toyota, I. Hirakawa, Y. Ogino, S. Miyagawa1, S. Oda1, N. Tatarazako, T. Miura, J.K. Colbourne, and T. Iguchi. 2013. A mutation in the receptor methoprene-tolerant alters juvenile hormone response in insects and crustaceans. Nature Communications 4, Article number:1856doi:10.1038/14 May.

> Most of the insects use juvenile hormone III as the innate juvenile hormone ligand. By contrast, crustaceans use methyl farnesoate. Despite this difference, the **process of this ligand transition is unknown**. A single amino-acid substitution in the receptor Methoprene-tolerant has an important role during evolution of the arthropod juvenile hormone pathway. Microcrustacea Daphnia pulex and D. magna share a juvenile hormone signal transduction pathway with insects, involving Methoprene-tolerant and steroid receptor coactivator proteins that form a heterodimer in response to various juvenoids. Juvenile hormone-binding pockets of the orthologous genes differ by only two amino acids, yet a single substitution within Daphnia Met enhances the receptor's responsiveness to juvenile hormone III. These results **indicate that this mutation within an ancestral insect lineage contributed to the evolution of a juvenile hormone III receptor system. This is a theoretical study and has not strong response to the toxicity of methoprene.**

Monsanto Technology LLC, Missouri. Glyphosate formulations and their use for the inhibition of 5-enolpyruvylshikimate-3-phosphate synthase. 2010. US Patent number 7771736 B2. Available online at https://www.google.com/patents/US7771736.

> This is a documentation of a Monsanto research on glyphosate and its effect on the inhibition of some plant root enzymes and is provided to inform one of the potential side effects of glyphosate formulations that are not pure glyphosate active ingredient. The implications are a reduction in root function if high exposures travel to the root system and are sequestered there.

Moreno, Polo. 2007. Notes on the Stipulation Injunction and Order for Protection of California Red-Legged Frog. Endangered Species Program, California Department of Pesticide Regulation.

> California DPR memorandum that specifies care in application of pesticides in areas that are known or suspected CRLF habitat.

Mosquito and Vector Control Association of California NPDES Permit Coalition. 2013. MVCAC NPDES Permit Coalition 2011/2012 Annual Report, NPDES Vector Control Permit (Order No. 2012-0003-DWQ).

> This is the documentation of the vector control guidelines and restrictions in the NPDES Permit issued to MVCAC.

National Park Service. 2008. Yosemite. Invasive Plant Management Plan for Yosemite National Park. ESA. Available online at http://www.nps.gov/yose/learn/management/invasive.htm.

> The Invasive Plant Management Plan Update is used by Park resource managers to control non-native invasive species. Adaptive management would allow the park to assess the safety and effectiveness of herbicides considered for protecting Yosemite's biodiversity. It provides a framework for decision making and prioritization strategies that based upon the time tested paradigms of Adaptive and Integrated Pest Management. Two herbicides, glyphosate and aminopyralid are currently used in the park. Following the 2009 Big Meadow Fire in Yosemite, the Interagency Fire Management Team recommended applying a pre-emergent herbicide that to prevent cheatgrass from overtaking the meadow after the late-season fire. Since this specific chemical was not considered and evaluated in the 2008 IPMP, the park was unable to use this

new tool. Successful aspects of the IPMP, such as annual work plans, prioritization, minimum tool analysis, and education, and outreach, would continue to be implemented.

North Carolina Partners in Amphibian and Reptile Conservation (NCPARC). 2009. Observations on Herbicide Choices & Amphibian Conservation. Available online at http://www.ncparc.org/pubs/Herbicide%20Choices%20&%20Amphibian%20Conservation.pdf.

> This group advocates for less chemical use in both agriculture and urban settings. They suggest that because glyphosate is a non-selective systemic herbicide widely used for vegetation control. It is considered relatively non-toxic to humans and most terrestrial wildlife and as such has been marketed for years as environmentally-friendly. The chemical kills plants by inhibiting the activity of certain enzymes that are present only in plants. Glyphosate is the active ingredient in Roundup, which was manufactured exclusively by Monsanto until 2000, when the patent expired. Since then many other companies have developed their own glyphosate formulations. Monsanto reported that aquatic species were much more sensitive to the formulated product than to the technical grade glyphosate that was used to make Roundup. The higher toxicity of the formulations was determined to be due to the presence of POEA (polyethoxylated tallow amine) surfactants. As a precaution to prevent harm to aquatic life, When these formulations are applied to upland sites according to label instructions, the risk to surfactant-sensitive species is considered important when exposing fish and amphibians.

Olmstead, A.W. and G. LeBlanc. 2001. Temporal and quantitative changes in sexual reproductive cycling of the *Cladoceran Daphnia magna* by a juvenile hormone analog. *J. Exp. Zool. July 1;290 (2):148-155.*

> Cyclic parthenogens, such as the cladoceran, Daphnia magna, utilize both asexual (parthenogenetic) and sexual reproduction. Experiments were conducted with the juvenile hormone analog methoprene to test the hypothesis that members of the insect juvenile hormone/vertebrate retinoic acid family of transcription factors are involved in the regulation of sexual reproduction in daphnids**. Neither methoprene, food reduction, or crowding independently stimulated entry into the sexual reproductive phase of the daphnids**. However, the combination of food deprivation and crowding stimulated entry into the sexual reproductive phase characterized by an initial high production of males and the subsequent intermittent production of haploid egg-containing ephippia. Exposure to 160 nM methoprene along with food deprivation and crowding caused a significant reduction in the percentage of males produced during the early phase of the sexual cycle and significantly increased the percentage of males produced during the later stages of the cycle. Methoprene concentrations as low as 6.4 nM significantly reduced the number of resting eggs produced and proportionately increased the production of parthenogenetically-produced neonates. These experiments demonstrate that methoprene uncouples the coordinate production of males and resting eggs during the sexual reproductive period of D. magna. **Methoprene stimulates male offspring production and defers their production to latter stages of the sexual reproductive period, while inhibiting the production of resting eggs and promoting the continuance of parthenogenetic reproduction**. J. Exp. Zool. 290:148-155, 2001.

Olmstead, A.W. and G. LeBlanc. 2001. Low exposure concentration effects of methoprene on endocrine regulated processes in the crustacean *Daphnia magna*. Toxicol. Sciences 62:268-273.

> Methoprene similarly may exert toxicity to crustaceans by mimicking or interfering with methyl farnesoate, a crustacean juvenoid. We hypothesized that methoprene interferes with endocrine-regulated processes in crustaceans by several mechanisms involving agonism or antagonism of juvenoid receptor complexes. In the present study, characterizing and comparing the concentration-response curves for methoprene and several endpoints related

to development and reproduction of the crustacean Daphnia magna. Methoprene has multiple mechanisms of toxicity and low-exposure concentration effects. Methoprene reduced the growth rate of daphnids with evidence of only a single concentration.

Olmstead, A.W. and G. LeBlanc. 2003. Insecticidal juvenile hormone analogs stimulate the production of male offspring in the crustacean *Daphnia magna. Environ. Health Perspect*. June;111(7):919-924.

> Juvenile hormone analogs (JHAs) represent a class of insecticides that were designed specifically to disrupt endocrine-regulated processes relatively unique to insects. Recently we demonstrated that the crustacean juvenoid hormone methyl farnesoate programs oocytes of the crustacean Daphnia magna to develop into males. We hypothesized that insecticidal JHAs might mimic the action of methyl farnesoate, producing altered sex ratios of offspring. Daphnids were exposed chronically (3 weeks) to sublethal concentrations of methyl farnesoate, the JHA pyriproxyfen, and several nonjuvenoid chemicals to discern whether excess male offspring production is a generic response to stress or a specific response to juvenoid hormones. Only methyl farnesoate and pyriproxyfen increased the percentage of males produced by exposed maternal organisms. As previously reported with methyl farnesoate, acute exposure (24 hr) to either pyriproxyfen or the JHA methoprene caused oocytes maturing in the ovary to develop into males. We performed experiments to determine whether combined effects of a JHA and methyl farnesoate conformed better to a model of concentration addition (indicative of same mechanism of action) or independent joint action (indicative of different mechanisms of action). Combined effects conformed better to the concentration-addition model, although some synergy, of unknown etiology, was evident between the insecticides and the hormone. These experiments demonstrate that insecticidal JHAs mimic the action of the crustacean juvenoid hormone methyl farnesoate, resulting in the inappropriate production of male offspring. The occurrence of such an effect in the environment could have dire consequences on susceptible crustacean populations.

Relyea, R.A. 2005. The lethal impact of roundup on aquatic and terrestrial amphibians. *Ecological Applications* 15(4): 1118–1124.

> This author assembled communities of three species of North American tadpoles in outdoor pond mesocosms that contained different types of soil (which can absorb the pesticide) and applied Roundup as a direct overspray. After three weeks, he reports that Roundup killed 96–100% of larval amphibians (regardless of soil presence). I then exposed three species of juvenile (post-metamorphic) anurans to a direct overspray of Roundup in laboratory containers. After one day, Roundup killed 68–86% of juvenile amphibians. These results suggest that Roundup, a compound designed to kill plants, can cause extremely high rates of mortality to amphibians that could lead to population declines. This statement is far from reality. The exposures used were DIRECT OVERSPRAY of the mesocosm units which is completely arbitrary and unrealistic if the author intends to extrapolate the results to field exposures.

Rexrode, M., I. Abdel-Saheb, and J.L. Andersen. 2008. Potential Risks of Labeled S-Methoprene Uses to the Federally Listed California Red-Legged Frog. Pesticide Effects Determination. USEPA Biopesticide and Pollution Prevention Division. February 20.

> One of the important frog papers following disproved:

- Based on the results of this assessment, the following hypotheses can be rejected: The labeled use of S-methoprene: growth and viability of juvenile and adult CRLFs.causing mortality or by adversely affecting growth or fecundity;
- indirectly affect by reducing or changing the composition of food supply;
- indirectly affect critical habitat by reducing or changing the composition of the aquatic plant

community in the ponds and streams comprising the species' current range and designated critical habitat, thus affecting primary productivity and/or cover;

- indirectly affect critical habitat by reducing or changing the composition of the terrestrial plant community (i.e., riparian habitat) and habitat in the ponds and streams comprising the species' current range and designated critical habitat;
- modify critical habitat changing breeding and non-breeding aquatic habitat (via modification of water quality parameters, habitat morphology, and/or sedimentation);
- modify the designated critical habitat of the CRLF by reducing the food supply required for normal growth and viability of juvenile and adult CRLFs;
- modify the designated critical habitat of the CRLF by reducing or changing upland habitat within 200 ft of the edge of the riparian vegetation necessary for shelter, foraging, and predator avoidance.
- modify the designated critical habitat of the CRLF by reducing or changing dispersal habitat within designated units and between occupied locations within 0.7 mi of each other that allow for movement between sites including both natural and altered sites which do not contain barriers to dispersal.
- modify the designated critical habitat of the CRLF by altering chemical characteristics necessary for normal response line, having a threshold of 12.6 nM.

> Molt frequency was reduced by methoprene in a concentration-dependent manner, at 4.2 and 0.21 nM a NOEC of 32 nM. Methoprene reduced fecundity 24 and <0.18 nM. Claim that methoprene elicits significant toxicity to endocrine-related processes in the 5–50 nM concentration range. Molting and reproduction were impacted at significantly lower methoprene concentrations, with a distinct concentration response and a threshold of <0.2 nM.

> The conclusion is that there is a "may affect", but "not likely to adversely affect" determination for the CRLF from the use of S-methoprene.

Seneff Stephanie. MIT Computer Laboratory. ND. Various Media submissions as nonpublished documents.

> Stephanie Seneff . is an Independent Scientist and Consultant, Computer Science and Artificial Intelligence Laboratory, MIT, Cambridge, MA 02139, USA. Critique on Dr. Seneff's views on the role of glyphosate in the production of diseases and the links to childhood problems. From other researchers "However she, has not actually performed any research into glyphosate. She is a Senior Research Scientist at the MIT Computer Science and Artificial Intelligence Laboratory." Therefore, it is misleading to cite her as a researcher and authority. She has published only speculations and gives many presentations, but has not created any new data.

Stark, J.D. 2005. A Review and Update of the Report "Environmental and health impacts of the insect juvenile hormone analogue, S-methoprene" 1999 by Travis R. Glare and Maureen O'Callaghan. Report for the New Zealand Ministry of Health.

> After ingestion by the target organisms the crystals dissolve and release the toxic proteins that then kill the organism.

> Conclusions of this report were: 1) although methoprene is toxic to 12 orders of insects and may have effects on other nontarget organisms, particularly other nontarget arthropods, methoprene is one of the least environmentally damaging mosquito control agents and poses little risk to human and animal health. 2) In fact, the concentrations of methoprene necessary to control mosquitoes (1 part per billion) are often much lower than the concentrations necessary to cause damage to populations of many nontarget organisms.

> Methoprene has a short half-life in the environment making it unlikely to accumulate in various environmental compartments. Although new literature has been published showing declines in insect biomass due to long-term use of methoprene and Bti in freshwater wetlands in Minnesota, USA, **no evidence for permanent damage to ecosystem function has been found.**

> Additionally, a concern discussed in the original assessment was the possibility that methoprene may be the cause of limb malformations being detected in frogs in the USA. Even though it has been six years since the last assessment, the causal agent(s) of frog deformities in the USA has still not been clearly elucidated. Some scientists believe that these deformities are caused primarily by a parasitic trematode, not methoprene. Others believe that a combination of several factors, such as trematodes, UV radiation and chemicals may be working synergistically to cause the observed malformations. It is my opinion that the conclusions reached by Glare and O'Callaghan in 1999 are still valid today and I would **recommend that methoprene be the first choice for control and eradication of introduced mosquito species.**

Thomson, J. and M. Ahluwalia. 2015. Bee-killing pesticides: The fight ramps up. CBC News. May 21

> A media report on the condition and status of bees and bee colonies suggesting a connection of pesticides (especially neonicotinoids) to reductions in bee populations. Reports that CCD cases have declined substantially in Canada over the last several years.

USDA Forest Service. 2003. Human and ecological risk assessment of nonylphenol polyethoxylate-based (NPE) surfactants in Forest Service herbicide applications. Unpublished report written by David Bakke, Pacific Southwest Region Pesticide-Use Specialist. May.

> Report summarizes some USFS risk assessment work on herbicides (report not provided by commenters, but it was retrieved from the internet posting of the USFS. The Forest Service uses herbicides with a common component nonylphenol polyethoxylate (NPE) found in these commercial surfactants at rates varying from 20 to 80%. Nonylphenol (NP) and NPE exhibit some estrogen-like properties although are much weaker than the natural estrogen estradiol. The author suggests that the low hazard quotients for accidental exposure scenarios exceed a level of concern. While the accidental exposure scenarios are not the most severe one might imagine they are representative of reasonable accidental exposures. The report further suggests that the expected chronic exposure levels, there is little risk to terrestrial wildlife at any application rate considered in this risk assessment. With the typical application rates, two scenarios represent a slight risk of effects to mammals: direct spray to a small mammal (assuming the skin affords no protection) and consumption of contaminated vegetation by a large grazing mammal, such as a deer. None of the other acute exposures at the typical rates of application represent a risk of effects to terrestrial wildlife.

US Environmental Protection Agency (USEPA).1991. RED Facts: Methoprene. Pesticides and Toxic Substances, Washington, DC. March.

> Source of pesticide information about toxicity, safety, handling and application guidance for Methoprene including all registration and testing information.

US Environmental Protection Agency (USEPA). 2012a. FIFRA: Risk Assessment Methods Process for pollinator risk assessment framework. USEPA Science Advisory Panel, September. Available online at http://www.epa.gov/pollinator-protection/fifra-peer-review-proposed-risk-assessment-methods-process.

> New test methods being developed to evaluate the effect of pesticides on pollinators with indications of new laboratory tests that may be incorporated into the FIFRA guidance.

US Environmental Protection Agency (USEPA). 2012b. Test Guidelines for Pesticides and Toxic Substances. Series 850 under FIFRA, TSCA, and FFDCA. June. Available online at http://www.epa.gov/test-guidelines-pesticides-and-toxic-substances/series-850-ecological-effects-test-guidelines.

> New test methods being developed to evaluate the effect of pesticides on pollinators are provided and the potential methods to be used with indications of new laboratory tests that may be incorporated into the FIFRA guidance.

US Environmental Protection Agency (USEPA) 2015. "Interim Use Limitations for Eleven Threatened or Endangered Species in the San Francisco Bay Area," "San Francisco Bay Area Endangered Species Litigation - Center for Biological Diversity v. EPA," "Court Issues Stipulated Injunction Regarding Pesticides and the California Red-legged Frog," "Endangered Species Case – Northwest Center for Alternatives to Pesticides v. EPA," and "Endangered Species Case - Washington Toxics Coalition v. EPA." Available online at http://www.epa.gov/endangered-species.

> A record of the proceedings in a court case suing EPA by two environmental activist groups indicating the EPA is not doing enough to protect the CLRF, especially the restrictions and de-listing of the pesticides that these activists suggest adversely impact the CLRF. The suit claims to provide additional guidance and potential regulatory limits on use numerous pesticides suggesting a potential causal adverse impact on the CRLF. USEPA sponsored reply and approach to address concerns about the CRLF but has little causal connection to actual pesticide uses.

US Environmental Protection Agency (USEPA). 2015. New Labeling for Neonicotinoid Pesticides / Protecting Endangered Species from Pesticides. Available online at http://www2.epa.gov/pollinator-protection/new-labeling-neonicotinoid-pesticides and http://www.epa.gov/espp/litstatus/effects/redleg-frog/permethrin/determination.pdf.

> New information and suggested restrictions and label changes that are intended to reduce the possible impacts of these pesticides on bees and bee colonies.

US Environmental Protection Agency (USEPA). 2016. Colony Collapse Disorder. Available online at http://www.epa.gov/pollinator-protection/colony-collapse-disorder.

> Describes the Colony Collapse Disorder as the phenomenon that occurs when the majority of worker bees in a colony disappear and leave behind a queen, plenty of food and a few nurse bees to care for the remaining immature bees and the queen. Once thought to pose a major long term threat to bees, reported cases of CCD have declined substantially over the last five years. The number of hives that do not survive over the winter months – the overall indicator for bee health – has maintained an average of about 28.7 percent since 2006-2007 but dropped to 23.1 percent for the 2014-2015 winter. While winter losses remain somewhat high, the number of those losses attributed to CCD has dropped from roughly 60 percent of total hives lost in 2008 to 31.1 percent in 2013; in initial reports for 2014-2015 losses, CCD is not even mentioned.

Walker, A.N, P. Bush, J. Puritz, T. Wilson, E.S. Chang, T. Miller, K. Holloway, and M.N. Horst. 2005. Bioaccumulation and metabolic effects of the endocrine disruptor methoprene in the lobster, *Homarus americanus. Integr. Comp. Biol.* 45:118-126.

> Methoprene has toxic effects on larval and adult crustaceans. Subsequently, the seasonal lobster catches from the WLIS have decreased dramatically. The lethality of the pesticides to lobsters had been unknown. We studied the effects of methoprene while other investigators studied effects of the other pesticides. Effects on larvae, adults or both, could have contributed to this decline. We found that low levels of methoprene had adverse effects on lobster larvae. It was toxic to stage II larvae at 1 ppb. Stage IV larvae were more resistant, but did exhibit

significant increases in molt frequency beginning at exposures of 5 ppb. Juvenile lobsters exhibited variations in tissue susceptibility to methoprene: hepatopancreas appeared to be the most vulnerable, reflected by environmental concentrations of methoprene inhibiting almost all protein synthesis in this orga suggesting that methoprene affects the normal pathway of lobster cuticle synthesis and the quality of the post-molt shell. Although it is likely that a combination of factors led to the reduced lobster population in WLIS, methoprene may have contributed both by direct toxic effects and by disrupting homeostatic events under endocrine control.

Williams. B. et al., eds. 1994. Assessing Pesticide Impacts on Birds. Final Report of the Avian Effects Dialogue Group, 1988-1993. RESOLVE, Center for Environmental Dispute Resolution. Williams, B. et al., Editors.

> This is the final report of the Avian Effects Dialogue Group's five year meetings to evaluate and rank the potential for laboratory tests to project likely effects of pesticides in actual field applications. The panels included government, industry, university and private scientists who brought real life experience and information to the discussions. The resulting information helped to direct and revisit many of the testing protocols used in the USEPA pesticide registration process. The results indicate that few laboratory tests actually predict possible field effects without large uncertainty. The USEPA uses many of the recommendations to review and design new, more appropriate test guidelines.

Williams T., J. Valle, and E. Vinuela. 2003. Is the naturally derived insecticide Spinosad® compatible with insect natural enemies? *Biocontrol Science and Technology* 13:459–475.

> Reports the relative efficacy and nontarget toxicity of spinosad and reports that "spinosad is highly active against Lepidoptera but is reported to be practically nontoxic to insect natural enemies" .In their studies, very large direct doses of spinosad in laboratory setting were toxic to nontarget insect predators, while low doses did not exhibit the same level of toxicity to non-targets and was relatively safe against the bulk of the insect predators.

World Health Organization. 2015a. Carcinogenicity of tetrachlorvinphos, parathion, malathion, diazinon, and glyphosate. *The Lancet* May;16:490-91.

> Very conservative report of the UN IARC, and using the precautionary principle it reported that glyphosate, and some of the other pesticides reviewed are "possibly carcinogenic.

World Health Organization. 2015b.Evaluation of five organophosphate insecticides and herbicides. Includes rebuttal discussions. *IARC Monographs* 112.

> Actual WHO report provided by the JMPR panel for toxicology. Includes an explanation of their role and mission of the panel membership of the JMPR of the World Health Organization in the United Nations. This panel provides a very conservative report of the UN IARC, and using the precautionary principle it reported that glyphosate, and some of the other pesticides reviewed are "possibly carcinogenic."

World Health Organization (WHO). 2015c. Joint FAO/WHO Meeting on Pesticide Residues (JMPR). Available online at http://www.who.int/foodsafety/areas_work/chemical-risks/jmpr/en/ [accessed October 1, 2015].

> Explanation and panel membership of the JMPR of the World Health Organization in the United Nations. This panel provides a very conservative report of the UN IARC, and using the precautionary principle it reported that glyphosate, and some of the other pesticides reviewed are "possibly carcinogenic.

Wu, X., D.H. Bennett, B. Ritz, J. Frost, D. Cassady, K. Lee, and I. Hertz-Picciotto. 2011. Residential insecticide use in Northern California homes with young children. *Journal of Exposure Science and Environmental Epidemiology* 21: 427-436.

> Residential insecticide usage and actual application details were collected in a population-based sample of 477 households residing within 22 counties in northern California with at least one child of age ≤ 5 years between January 2006 and August 2008. Altogether, 80% of the households applied some type of insecticide in the previous year, with half of this population using two or more application methods. Of the households using insecticides, half reported applying insecticides relatively infrequently (<4 times per year), whereas 11-13% reported high frequency of use (>24 times per year). Application frequency was temperature dependent, with significantly more applications during the warmer months from May through October. Spot treatments appeared to be the most prevalent application pattern for sprays. For one out of three of the indoor applications, children played in the treated rooms on the day of the application, and for 40% of the outdoor applications, pets played in the treated area on the day of the application. These authors report that describing the intensity of insecticide use and accompanying behaviors in families with young children may inform future insecticide exposure modeling efforts, and ultimately, risk assessments

Zhang, X. Hu, J.Luo, Z. Wu, L. Wang, B. Li, Y. Wang, and G. Sun. 2015. Degradation dynamics of glyphosate in different types of citrus orchard soils in China. *Molecules* 20: 1161-1175.

> In this study, the degradation dynamics of glyphosate in different types of citrus orchard soils in China were evaluated under field conditions. Glyphosate soluble powder and aqueous solution were applied at 3000 and 5040 g active ingredient/hm2, respectively, in citrus orchard soils, and periodically drawn soil samples were analyzed by high performance liquid chromatography. The results showed that the amount of glyphosate and its degradation product aminomethylphosphonic acid (AMPA) in soils was reduced with the increase of time after application of glyphosate formulations. Indeed, the amount of glyphosate in red soil from Hunan and Zhejiang Province, and clay soil from Guangxi Province varied from 0.13 to 0.91 μg/g at 42 days after application of aqueous solution. The amount of glyphosate in medium loam from Zhejiang and Guangdong Province, and brown loam from Guizhou Province varied from less than 0.10 to 0.14 μg/g, Overall, these findings demonstrated that the degradation dynamics of glyphosate aqueous solution and soluble powder as well as AMPA depend on the physicochemical properties of the applied soils, in particular soil pH, which should be considered in the application of glyphosate herbicide.

Zoecon Corporation. 1974. Technical bulletin on Altosid. Toxicological properties.

> Technical bulletin describing the physiochemical characteristics of Altosid (methoprene) with information on applications restrictions, and target species. This bulletin was updated at least once by USEPA in 2001.

Bill A. Williams PhD

Current Position
Senior Consultant & Risk Assessor

Discipline Area
> Ecological & Human Health Risk Assessments
> Natural Resource Damage Assessments
> Environmental Site Assessments
> Probabilistic Risk Assessments
> Toxicology
> Biomarker Research
> Mitigation Strategies

Years' Experience
47 Years

Joined Cardno
2009

Education
> National Academy of Sciences Post-Doctoral 1968-1970
> PhD, Physiology & Biophysics, University of Illinois, Urbana, 1968
> MS, Physiology & Biophysics, University of Illinois, Urbana, 1965
> BA, Physiology & Biophysics, University of California, Berkeley, 1963

Affiliations

www.cardno.com

Summary of Experience

Dr. Williams has more than 40 years of experience and expertise in environmental risk assessment and toxicology including CERCLA, NRDA, NEPA, and CEQA projects ranging from upland to sediment to freshwater/marine projects. Dr. Williams has been a member of numerous international, National Academy, and federal committees and workshops to define risk assessment guidelines, test procedures, field study approaches, and avian and mammalian test protocols, and provide other technical assistance utilized by USEPA regulators. He helped develop USEPA's Framework for Ecological Risk Assessment and USEPA's risk assessment of 2,3,7,8 TCDD. He was a charter member of the Avian Dialogue Group, convened by the Conservation Foundation (RESOLVE) to bring industry, academia, and government regulators together to resolve conflicts between the groups. Dr. Williams has led and supported dozens of successful projects that were acceptable to the Washington Department of Ecology, Oregon Department of Environmental Quality, Oregon Department of Fish and Wildlife, US Environmental Protection Agency, Region X, and numerous other USEPA regions nationwide. Dr. Williams has served on several Oregon DEQ advisory science committees and workshops. He has been a member of several national and regional EPA Science Advisory Panels, including the SAP panels on endocrine disruptors, uncertainty in risk assessments, and the panel on use of laboratory data in estimates of risk to wildlife.

Significant Projects

Expert Witness-Senior Consultant- Ecological Risk Estimates and Development of Integrated Pest Management Guidance for Pesticides for Mid-Peninsula Open Space District, Los Altos, California.

Dr. Williams provided strategic and scientific support in the development of an Integrated Pest Management (IPM) system for use by the Mid-Peninsula Open Space District. The IPM is tailored to the vectors of concern, the pesticides and herbicides used by the District, and potential risk to the non-target aquatic and terrestrial species. Pesticides incorporated into the IPM were based on evaluations of the use of more than 20 herbicides (with emphasis on use of glyphosate in regional wildland areas for control of over 60 invasive plant species), dozens of insecticides, structural and nuisance agricultural and urban pests, and selected regional wildlife pests. The IPM developed for the District included control of ants, cockroaches, wasps and flies, ticks, and mosquitoes. The IPM plan included recommendations for establishing and conducting pest identification, conducting damage assessments, establishing tolerance levels and several tiers of proposed vector control that addressed top to bottom elements of implementation strategies. The IPM delivered to the District included more than 120 pages of evaluations and recommendations, including extensive quantitative Ecological and Human Health Risk assessments. Dr. Williams prepared and supported draft and final documents and graphics for use in public meetings relating to the results of the studies.

Expert Witness-Senior Consultant- Ecological Risk Estimates and Development of Herbicide Risks to Non-target vegetation and Wildlife in California Wildfire Areas for the California Department of Forestry & Fire Protection (CAL FIRE).

Dr. Williams provided scientific reviews and risk assessments addressing the potential adverse effects of CAL FIRE herbicide use to reduce the potential for and mitigation of wildfires in California. The Vegetation Treatment Program (VTP) project included evaluation of potential adverse impacts of herbicides used in forestry and rangeland to control brush

- Society of Environmental Toxicology & Chemistry
- Pacific Northwest Society of Environmental Toxicology & Chemistry

and grasses and for maintenance of areas that have been previously cleared of heavy vegetative fuels. The primary herbicides of concern in the evaluation were the numerous products containing glyphosate as the active ingredient. Glyphosate was one of the most effective herbicides for control of the vegetation that provides potential fuel for wildfires. Control of this vegetation is the target of the CAL FIRE VTP management process statewide. Because vegetation control treatments are not appropriate in all locations and can cause environmental impacts, the recommendations were designed for site specific conditions in the wide range of wildfire environments in the State. In response to the need for their VTP, comprehensive guidelines were developed for the practical management and operation of the VTP including prioritization, selection, assessment, and mitigation of appropriate vegetation treatments. The reviews and documents provided to CAL FIRE for its Vegetation Treatment Program provides the framework that is being used for the implementation of appropriate fuels treatments across non-federal lands in California.

Senior Consultant- Ecological Risk Estimates of Pesticides for Nine Mosquito/Vector Control Districts, Northern California

Dr. Williams is providing strategic and scientific support in the development of the ecological and human health assessments of commercial pesticide product applications (46 active ingredients and adjuvants) for the control of mosquitoes and other vectors of human diseases and discomfort in nine counties of California. Providing impact analyses for both chemical and nonchemical treatment methods of control in Programmatic Environmental Impact Reports (under CEQA) for the nine districts/agencies in the San Francisco Bay Area and Monterey County. . The impact analyses considered the toxicity and fate and transport of the active ingredients based on a literature review including ultra-low volume (ULV) spray applications. Also included were herbicides for the control of mosquito-breeding habitat.

Senior Consultant/Technical Advisor/Ecological Risk – Passaic River Project, Newark, New Jersey, Passaic Coordinating Partners Group (CPG)

Providing strategic and conceptual support to a member of the CPG for their Passaic River facility. Developing strategy and proactive approaches to CERCLA and NRDA mitigation and restoration options. Working with CPG member to define their potential risk, and strategy for acceptable allocation within the Consortium of PRPs on the Passaic River. Providing comprehensive evaluation of Ecological and Human Health risks. Providing on-going technical review of all on-going work, including existing work plans, schedules, and work elements to develop new plans and approach to streamline the schedule and to reduce costs.

Senior Consultant- NRDA-Gulf of Mexico

Dr. Williams is on the Cardno NRDA team responding to the Deepwater Horizon accident and oil spill in the Gulf of Mexico on behalf of BP Exploration & Production Inc. (BP). Bill has provided support to the Terrestrial Mammal and Bird Technical Working Groups (TWG) and participated in the design or implementation of the cooperative NRDA studies included in those TWGs.

Senior Consultant- Ecological Risk Estimates of Contamination at a Golf Course in Southern California

Dr. Williams provided strategic and scientific support in the development of the risk estimates of commercial use and application of herbicides for the control of unwanted vegetation of California. Prepared documents and graphics for use in discussions and public meetings relating the results of the studies. Confidential Client.

Senior Scientist – Evaluation of Mercury and Other Contaminants in Outfall Plumes, Port Gamble, Washington and Mare Island Site, City of Vallejo

Evaluated and critiqued contaminants detected in facility outflow, and estimate risk to aquatic and terrestrial resident and endangered species. Prepared presentation approaches and materials for discussions with U.S. Environmental Protection Agency (EPA) Region 10.

Senior Project Manager – Ecological Risk Assessment, Whitefish River, Montana, Burlington Northern Santa Fe

Developed an ecological risk assessment for a river adjacent to a railroad fueling facility. Reviewed results of initial sampling of sediment in the river to identify preliminary chemicals of potential ecological concern, and then prepared a sampling and analysis plan for additional studies needed to conduct the risk assessment, including co-located sediment and benthic samples. Compared the results of the benthic community analysis with chemical data for co-located sediment samples to evaluate whether chemicals in sediment were resulting in toxicity to the benthos or whether physical conditions were responsible for changes in the benthic communities. The risk assessment estimated potential risks to resident and endangered ecological receptors, and identified protective sediment concentrations of PAHs and PCBs for the most sensitive ecological receptors.

Senior Project Manager – Probabilistic Risk Assessments, Southeastern U.S.; FMC Corp. and American Cyanamid, Princeton, New Jersey; and Novartis, Inc. and Rhone Poulenc, Durham, North Carolina

While employed by Kennedy Jenks, conducted probabilistic risk assessments to assess potential risks from application of pesticide to agricultural crops in southeastern United States. This risk assessment was conducted to evaluate numerous application and exposure scenarios that might result in risk to aquatic and terrestrial resident, endangered, and other non-target wildlife. Results from these studies are being used to evaluate the potential use of probabilistic risk assessment to evaluate the appropriateness of EPA restrictions on the labeling of the pesticide.

Senior Risk Assessor – Human Health and Ecological Risk Assessments, Spokane, WA, Teck Cominco America

Provided strategic support and risk assessments for a potential Superfund listing for Lake Roosevelt, Washington Presented approaches to EPA Region 10 for the development of the characterization, RI/FS, and potential NRDA for Lake Roosevelt. As Senior NRDA advisor and risk assessor, provided strategic support and risk assessments in support of a potential Superfund listing for Lake Roosevelt. Aquatic, sediment, and upland sources in the lake were being characterized for the potential cleanup of metals and other contaminants.

Expert Witness – Ecological Risk Assessment, Columbia River Basin, Bellevue, Washington, Northwest Pulp and Paper Association,

Provided expert evaluation and testimony concerning the impact of pulp and paper effluents, including dioxin and other organochlorines, on populations of Bald Eagles in the Columbia River Basin. The focus of the project was to determine the extent of potential exposure and possible effects of pulp mill operations on the Bald Eagle population in the Columbia River Basin. An ecological risk assessment was conducted that focused on the reproductive success and population dynamics of resident and endangered species, especially the Bald Eagles in the region. As a result of the assessment, it was concluded that the number of nesting pairs of Bald Eagles in the region had far surpassed the U.S. Fish and Wildlife Service Recovery goals, and that the population of eagles in the region was actually vigorous and strong. The results of the study were presented at open congressional hearings and to the Department of Interior. Shortly thereafter, DOI changed the listing from Endangered to Threatened with caveats for several regions.

Consultant – Human Health Risk Assessments, Klamath Falls, Oregon

Provided strategic support and risk assessments for a site contaminated with asbestos and heavy metals. Developed sampling and analysis protocols, data objectives, and soil risk triggers for adults, children, and pets. Provided several risk scenarios for exposure to both the buried and surface asbestos, including evaluation of ACM and inert moieties. Provided expert testimony and presentations for the plaintiffs.

Senior Risk Assessor – Ecological Risk Assessment, Eugene, OR, L.D. McFarland, Colorado

Provided an ecological risk assessment of pentachlorophenol and copper on freshwater fish and other aquatic species. Provided study plan, sampling plan, and fish residue testing oversight. Provided complete review of aquatic residue data, including hazard and exposure data for use in the preliminary ecological risk assessment. The focus was the impact of a spill of lumber treatment products on fish and benthic invertebrates in two small sport-fishing ponds. The spill included products containing creosote and substantial amounts of PCPs. Although there was substantial mortality of some fishes, it was determined that the impact would be short-lived, and that the ponds could be used for sport fishing after a period of a few months without additional mitigation. The results and recommendations of the project were accepted by the Oregon Department of Fish and Wildlife.

Senior Risk Assessor – Environmental Risk Assessment, Refinery Terminal Site, Willamette River, Portland, Oregon, Texaco/Equilon

Conducted human health and ecological risk assessments focusing on the potential risk of upland operations and river sediments at a refinery terminal site on the Willamette River. Constituents of concern included benzene, toluene, ethylbenzene, and xylene (BTEX); metals; and PAHs. The project was conducted according to the Oregon Department of Environmental Quality Risk Assessment guidelines.

Senior Risk Assessor – Environmental Risk Assessment, Nine Navy Bases in the San Francisco Bay Area, San Bruno, California, U.S. Navy

Conducted human health and ecological risk assessments for nine Navy bases in the San Francisco Bay area. Developed and instituted guidance for Feasibility Study Design, and provided mitigation strategies based on protective concentrations of contaminants acceptable to the Regional Boards, the U.S. Navy, and other regulators. Project involved use of innovative approaches to refining ecological estimates of exposure to higher trophic level receptors. Approach included site-specific and realistic estimates of doses to receptors using probabilistic techniques, and resulted in the innovative approach to development of “protective chemical levels” (PCLs) still in use by regulators and other environmental assessors.

Senior Risk Assessor – Environmental Sampling and Risk Assessment, Walnut Creek, California, Carollo Engineers

Provided project and sampling plan oversight and scientific support to a risk-based analysis of the contribution of publicly owned treatment works (POTW) effluent to waterways, including risk to aquatic organisms and birds at sites in northern California. Risk assessment has focused on effluents and contamination according to the National Toxics Rule, the California Toxics Rule, and EPA Ambient Water Quality Criteria guidelines. Constituents evaluated included organics, metals, and PAHs.

Senior Risk Assessor – Ecological Risk Assessment, Washington, DC, U.S. Environmental Protection Agency (EPA)

Produced a series of wildlife toxicity profiles for PCBs for use by EPA as guidelines for acceptable exposure levels of PCBs to birds and mammals. In addition to acute toxicity profiles, the report also presented thresholds and acceptable exposure levels for reproduction, growth, and immunological endpoints. The report was used as a preliminary guideline, and was incorporated into EPA wildlife exposure handbooks

Senior Risk Assessor – Ecological Risk Assessment, Washington, DC, EPA

Developed position documents for the EPA Office of Toxic Substances for the risk of dioxin to terrestrial wildlife methods to provide predictive impacts on birds and mammals. In addition to acute toxicity profiles, the report also presented thresholds and acceptable exposure levels for reproduction, growth, and immunological endpoints. The report was used as a preliminary guideline, and was incorporated into EPA wildlife exposure handbooks for dioxin.

Senior Risk Assessor and Expert Witness – Ecological Risk Assessments, Various Locations, Multiple Clients

While at EP&T, developed a series of comprehensive ecological risk assessments for new agricultural chemicals proposed for registration and chemicals due for re-registration according to the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Risk assessments included predictive risk to non-target aquatic and terrestrial wildlife. The results of the studies were prepared in formats acceptable to the state and EPA regulators. Clients included American Cyanamid, Princeton, NJ; Rhone-Poulenc, Durham, NC; Ciba Geigy Company; and Dow Chemical.

Workshops and Invited Panel Member

> Invited Speaker, “Implementing Probabilistic Ecological Assessments: A Consultation”. National Academy of Sciences Advisory Panel to USEPA, Washington, DC. 5-7 April 2001

> Invited Instructor. “Ecotoxicology for Hazard Communication”. Society of Chemical Hazard Communication Annual Meeting. Washington, DC. 3 October 1999

> Invited Panel Member, “Review of Probabilistic Risk Assessment for Chlorfenpyr”. National Academy of Sciences Advisory Panel to USEPA, Washington, DC. 23-24 September 1999

> Invited Panel Member, “Uncertainty Analysis in Ecological Risk Assessments” SETAC Workshop, Pellston, MI. August, 1995

> Invited Panel Member, Session Chair, SETAC/OECD Joint Workshop on Avian Toxicity Laboratory Testing. Pensacola, FL. 4-7 December 1994

> Program Chair. Ecotoxicological Principles for Avian Field Studies. SETAC Pellston Workshop on Radiotelemetry for Avian Field Studies. Asilomar, CA. January 1993

> Invited Panel Member, “Wildlife Criteria External Advisory Panel”. Washington State Department of Ecology, Olympia, WA. 1994-1998

> Invited Panel Member, “Environmental Effects Assessment Workshop”, USEPA, Office of Hazardous Waste, Seattle, Washington. 24-28 July 1988

> Invited Charter Member, “Avian Field Testing Dialogue Group”, The Conservation Foundation, Wash., DC. 1988-1992

> Invited Panel Member, “Risk Assessments for Land Application of Pulp and Paper Mill Sludge”, USEPA Workshop on Dioxin, Baltimore, MD. September 1991

- Invited Panel Member, Session Chair, SETAC Pellston Workshop on the Population Ecology and Wildlife Toxicology of Agricultural Pesticide Use: A Modeling Initiative for Avian Species. Kiawah Island, S. Carolina. July 1990
- Panel Panel Member, “Standing Committee on Ecotoxicology of the Risk Assessment Council, USEPA, Washington, DC. 1987-1988
- Invited Panel Member, “Terrestrial Environmental Risk Assessments” in the Organization of European Council of Development” Conference, Wash, DC. 13-17 June 1988
- Chair and Panel Member “Critical Ecosystems of Concern,” Oregon State University. September 1987
- Invited Panel Member, SETAC Conference, “Research Priorities in Ecological Risk Assessment,” Breckenridge, Colorado. August 1987

Chair/Session Organizer Technical Meetings

- Session Chair: Emerging Pollutants. Society of Environmental Toxicology and Chemistry. November 14-18, 2004, Portland, Oregon
- Organizational/Program. Pacific Northwest Society Environmental Toxicology and Chemistry. April, 2004. Port Townsend, WA.
- Session Chair: Applications of Ecotoxicology to Real World Problems. Society Environmental Toxicology and Chemistry. November 7-12, 2003, Austin Texas
- Session Chair. Exposure and Effects Endpoints. Society Environmental Toxicology and Chemistry. November 7-12, 2003, Austin Texas
- Organizational/Program Co-Chair. Pacific Northwest Society Environmental Toxicology and Chemistry. May, 2002, Portland, Oregon
- National Academy of Sciences Risk Assessment Task Force (1988-1990)
- Wildlife Toxicology Special Session on Acetylcholinesterase Assays in the Field. 10th Society Environmental Toxicology and Chemistry. Toronto, Canada. 29 October – 3 November 1989
- ASTM Committee on Field Protocols for Wildlife Population Studies (1987-1990)
- ASTM Committee on Acetylcholinesterase Determination in Field Studies (1988)
- Wildlife Toxicology Session Chair, 8th Society Environmental Toxicology and Chemistry, Pensacola, Florida. 9-12 November 1987
- Wildlife Toxicology Session Chair, 7th Society Environmental Toxicology and Chemistry, Washington, DC. 3-6 November 1986
- Acetylcholinesterase Assay Symposium Chairman, VII Society Environmental Toxicology and Chemistry, Washington, DC. 3-6 November 1986
- Wildlife Toxicology Session, 6th Society Environmental Toxicology and Chemistry, St. Louis, MO. 8-22 November 1985
- General Conference Chairman, Wildlife Toxicology Symposium, Portland, OR. January 1984

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4 Individual Comments and Responses

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I-Dic

Comment from Pat Dickens

I would like to register a comment not to use chemicals in West Marin. We have so many organic gardens and farms here. 1

Pat Dickens
Bolinas

Comment Letter I-Dic — Dickens, Pat

Response 1

For many years, the District has cooperated closely with organic growers and businesses throughout the Service Area. As a result, no adverse consequences to organic agriculture have been reported. As part of the Proposed Program, the District will continue its consultation and cooperation with organic growers and businesses. Vector control materials certified and labeled for organic use will be used as appropriate in conjunction with organic operations and accompanying organic operation plans.

The District uses several biorational formulations of mosquito larvicides that contain three bacterial active ingredients that are found in nature. Certain formulations containing these active ingredients are labeled for use with organic crops by the Organic Materials Review Institute and the USEPA. Examples of bacteria pathogenic to mosquitoes are *Bacillus sphaericus* (Bs), the several strains of *Bacillus thuringiensis israelensis* (Bti), and *Saccharopolyspora spinosa*. Two bacteria, Bs and Bti, produce proteins that are toxic to most mosquito larvae, while *Saccharopolyspora spinosa* produces compounds known as spinosysns, which effectively control all larval mosquitoes. Bs can reproduce in natural settings for some time following release. The Bti materials the District applies do not contain live organisms but only spores made up of specific protein molecules. All three bacteria are naturally occurring soil organisms that are also commercially produced for use as mosquito larvicides. These are the only three active ingredients approved for use in controlling larval mosquitoes when organic production is in progress.

One adult mosquito control product used by the District (Merus 2.0) is approved (by OMRI and the USDA National Organics Program) for use in conjunction with organic operations.

With respect to the issue raised by the commenter about chemical treatments for vector control in West Marin, the District operates under the terms of an agreement with a group known as the West Marin Mosquito Council (WMMC). The most recent version of the Agreement was approved by the District and WMMC in May 2016. The Agreement recognizes that the District may apply all the bacterial products discussed above, plus certain non-organic products, namely Agnique MMF, S-methoprene, and mosquito larvicide oils such as CoCoBear.

As discussed initially in the PEIR Program Description (Section 2.3.5.1.1), Agnique MMF is a very thinly applied (monomolecular) film product that acts as a larvicide and pupicide. Similarly, mosquito larvicide oils such as CoCoBear are applied as larvicides and pupicides where needed and appropriate. The WMMC Agreement also permits the use of s-methoprene, a mosquito growth regulator discussed in the PEIR Section 2.3.5.1.1. In the geographical region referred to by the commenter (West Marin), s-methoprene is applied only when necessary to Onsite Wastewater Treatment Systems (OWTS), also known as septic systems, to control larval mosquitoes. Under the District's policies and practices, Agnique, s-methoprene and larvicide oils are always used judiciously and in such a manner as not to interfere in any way with organic agriculture or production.

I-Fra1

Comment 1 from Mary Fraser

Dear District Board of Directors and Staff,
Please choose the No Chemical option from your draft PEIR. Pesticides drift, so you cannot guarantee anyone that you will not affect them. Pesticides get into our air and our water. I am attaching a speech that I recently wrote about pesticides, drift and their threat to the $45 million dollar agricultural market in Marin. 1

My name is Mary Fraser and I am a resident of Marin County. I am here today to ask you to ban the use of pesticides on Marin County Open Spaces and Parks. I am asking Parks and Open Space to become organic.

I want to share this graphic with you. For those of you who can't read it, it says: It's Raining Roundup. With a picture of a little girl playing in the rain. Below it, it says Monsanto's Roundup in 75% of Air and Rain Samples. This graphic has been created from a study done by the US Geological Survey. The following quotes are from their study.

"Pesticides can become airborne through volatilization and wind erosion of particles both during and after their application. Volatilization from treated areas is a continuous process and can be a major dissipative route for many pesticides. Airborne pesticides can be carried by wind and deposited in unintended areas by dry (gas and particle) and wet (rain and snow) deposition." This is what is commonly known as drift. 2

Marin County has organic agriculture that is worth $46 million dollars per yr. $46 million dollars per yr. There are 66 registered organic operations. The drift from the use of pesticides on Open Space and Parks may jeopardize that $46 million dollars or it may drift into more populated areas and contribute to health problems. No one knows where it will go. We just know that pesticides drift.

Coincidentally, I also just happened to sign up for the Marin Organic newsletter. I want to read you the reply I received.

Hi Mary,

I just wanted to send a quick note to thank you for signing up. 3

When the founders of Marin Organic first met in the mid-1990's they envisioned a county free of herbicides and pesticides and hoped that organic would become the new norm. Well, today we're proud to say that the majority of productive farmland in Marin County is certified

I-Fra1

organic. We're still here carrying on that mission, and part of that is educating folks through our newsletters.

Jeffrey Westman-Executive Director Marin Organic

Please join Marin Organics vision of Marin County as a place free of herbicides and pesticides.

Attached are documents regarding the USGS studies that I referenced above.

Mary Fraser

[redacted]

[redacted]

3

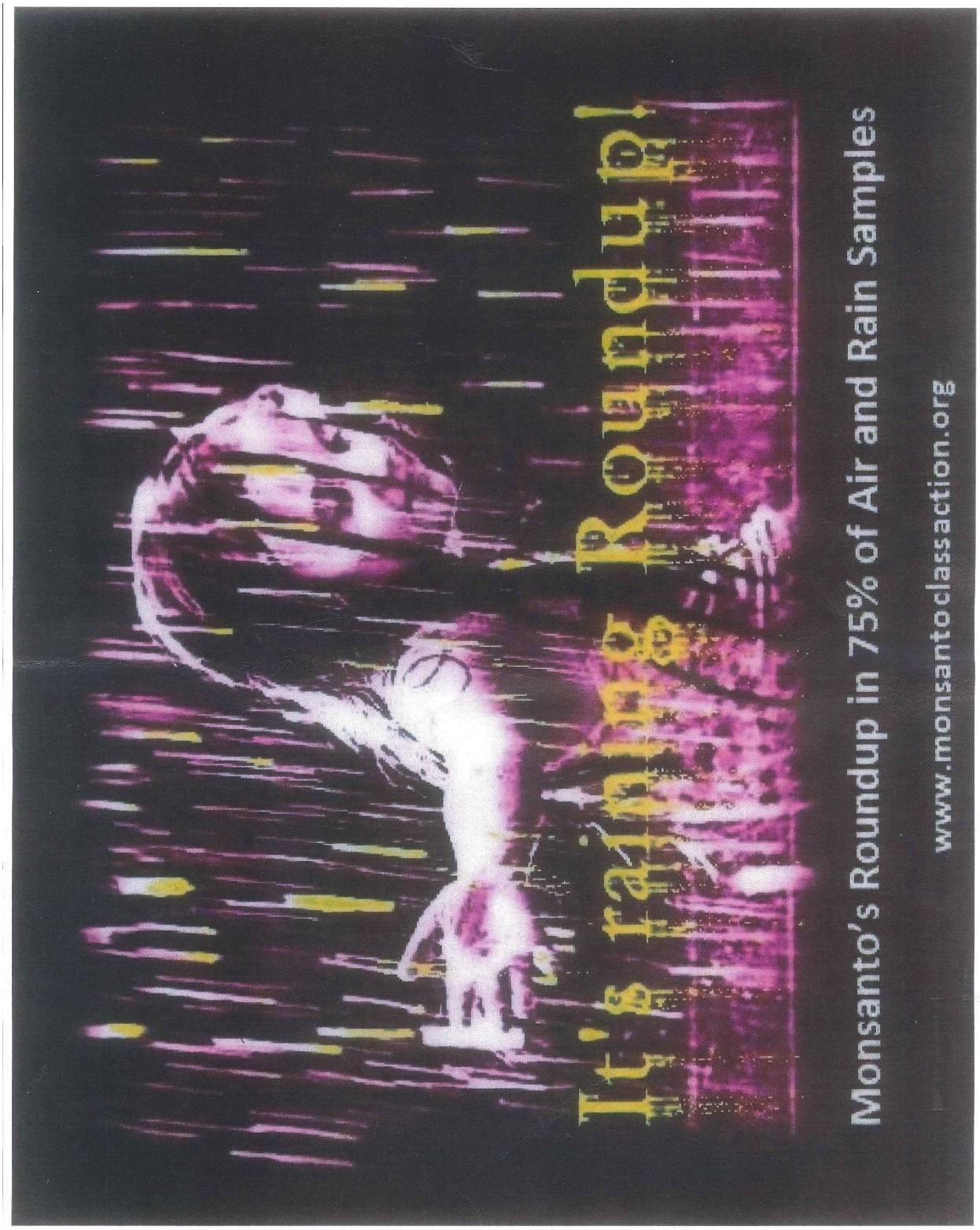
http://www.usgs.gov/newsroom/article.asp?ID=2909#.VfnIlNVViko

1. http://www.greenmedinfo.com/blog/roundup-weedkiller-found-75-air-and-rain-samples-gov-study-finds

   http://www.ncbi.nlm.nih.gov/pubmed/24549493

   http://www.ncbi.nlm.nih.gov/pubmed/18453431

   http://www.ncbi.nlm.nih.gov/pubmed/21128261


It's raining Roundup!
Monsanto's Roundup in 75% of Air and Rain Samples
www.monsantoclassaction.org

Comment Letter I-Fra1 Fraser, Mary

Response 1

The District minimizes the potential for drift from larvicide and adulticide applications by following the best management practices listed below in addition to meeting all label requirements:

> Postpone or cease application when predetermined weather parameters exceed product label specifications, when wind speeds exceed the velocity as stated on the product label, or when a high chance of rain is predicted and rain is a determining factor on the label of the material to be applied. (H6)

> Applicators will remain aware of wind conditions prior to and during application events to minimize any possible unwanted drift to waterbodies, and other areas adjacent to the application areas. (H7)

> Spray nozzles will be adjusted to produce larger droplet size rather than smaller droplet size. Use low nozzle pressures where possible (e.g., 30 to 70 pounds per square inch). Keep spray nozzles within a predetermined maximum distance of target weeds (e.g., within 24 inches of vegetation for hand application) or vectors. Adjusting droplet size would only apply to larvicides, herbicides, and non-ULV applications. Use ULV applications that are calibrated to be effective and environmentally compatible at the proper droplet size (about 10-30 microns). (H8)

The No Chemical Program was reviewed in Section 15.4.2 of the Draft PEIR. This comment will be considered by the District's Board of Trustees in its consideration whether to approve the Program as proposed, or with modifications.

Response 2

The District uses several formulations of mosquito larvicides which contain three bacterial active ingredients that are found in nature. Certain formulations containing these active ingredients are labeled for use with organic crops by the Organic Materials Review Institute and the USEPA. Examples of bacteria pathogenic to mosquitoes are *Bacillus sphaericus* (Bs), the several strains of *Bacillus thuringiensis israelensis* (Bti), and *Saccharopolyspora spinosa*. Two bacteria, Bs and Bti, produce proteins that are toxic to most mosquito larvae, while *Saccharopolyspora spinosa* produces compounds known as spinosyns, which effectively control all larval mosquitoes. Bs can reproduce in natural settings for some time following release. Bti materials applied by the District do not contain live organisms, but only spores made up of specific protein molecules. All three bacteria are naturally occurring soil organisms that are commercially produced for use as mosquito larvicides. These are the only three active ingredients referenced as being acceptable for use in mosquito habitat present on organic farms. Therefore, the District's use of these materials does not threaten the organic farming industry.

Concerning drift, see Response 1 above. There is potential for some infrequent applications of adulticides to impact residents and/or recreationists with objectionable odors. The materials have been used in the current Program, and people have not complained about odors. However, it is possible that complaints could occur in the future. As discussed in Section 10.2.7 (page 10-32):

> **Impact AQ-25:** The Chemical Control Alternative could subject people to objectionable odors. Impacts could be **potentially significant but mitigable**, even with BMPs implemented.

To mitigate Impact AQ-25, the District and its contractors may implement any of the following measures as applicable to the specific application situation to reduce drift towards human populations/residences from the ground and aerial applications of odorous treatment compounds:

Mitigation Measure AQ-25a: Whenever possible and practicable, defer application of treatment compounds until such time that favorable wind conditions would reduce or avoid the risk of drift into populated areas.

Mitigation Measure AQ-25b: Utilize equipment such as wind meters and global positioning system (GPS) tracking devices when applicable that assist in documenting site-specific compliance with all label requirements for drift mitigation.

Mitigation Measure AQ-25c: Use precision application technology to reduce drift and the total amount of material applied. This measure can include (1) Precision guidance systems that minimize ground or aerial spray overlap (e.g., GPS and Real Time Kinetics – GPS/RTK) and (2) Computer-guided application systems that integrate real-time meteorological data and computer model guidance to reduce drift from aerial application (e.g., trade names “AIMMS,” “Wingman™ GX,” and “NextStar™ Flow Control”).

Use of any one of these measures would reduce the impact to **less than significant**.

The impact to human health is less than significant as explained in Section 7.2.5 for herbicides and Section 7.2.7 for the other chemical control options. For more information on glyphosate, see our responses to your comments I-Fra3.

Response 3

Comment noted and considered. No response is necessary, as the letter was provided for informational purposes and does not address the PEIR.

Concerning the hyperlinks to material referenced as being from USGS, the following responses are provided.

> http://www.usgs.gov/newsroom/article.asp?ID=2909#.VfnllNVViko (USGS 2016)

This is a link to the primary USGS website that contains hundreds of links to research and other reports addressing numerous issues in health and environmental contamination. Although there are several reports listed that address glyphosate, they are generally addressing the same issues as the reports used in the PEIR including Appendix B. In the absence of a list of specific entries and links in the website, we can neither feasibly nor practically address or comment on any except for the specific ones where we have links provided by the commenter that are listed below. These studies appear to be focused on chemicals associated with agricultural uses and are not applicable to vector control.

> Sayer, Ji. 2014. Roundup Weedkiller Found In 75% of Air and Rain Samples, Gov. Study Finds. http://www.greenmedinfo.com/blog/roundup-weedkiller-found-75-air-and-rain-samples-gov- study-finds.

This represents an overview of the monitoring studies evaluating the chemicals detected in rain during several annual periods in Mississippi between 1995 and 2007 associated with agricultural pesticide spraying. Although there are numerous detected chemicals in the collected rainwater, the reports (this one and the two others by the same authors that focus on glyphosate) indicate the detections are very low (less than about 7 µgm per cubic meter, as an example). Using this estimated air concentration, the authors estimate that an individual breathing this level of chemical continuously might be subjected to about 27 billionths of a gram over a 24 hour period. The bulk of the summaries suggest substantial differences in chemicals detected between and among years of the study. They report that certain pesticides, but not always the same ones, seem to be dominate in the samples with detected chemicals present. It appears that these traces of chemicals were associated with specific agricultural practices. This is a summary of the studies conducted to evaluate the concentration of detectible chemicals in rain and air associated with agricultural pesticide spray events. The following report also addresses this monitoring technique.

> Majewski M.S. R.H. Coupe, W.T. Foreman, and P.D. Capel. 2014. Pesticides in Mississippi air and rain: a comparison between 1995 and 2007. *Environ Toxicol Chem.* Jun;33(6):1283-93. Available online at http://www.ncbi.nlm.nih.gov/pubmed/24549493.

  This is another publication using the same data as those in the prior citation. The assumptions and summaries are similar. It documents chemicals in collected in rain and attributes them to agricultural uses.

> Vogel, J.R., M.S. Majewski, and P.D. Capel. 2008. Pesticides in rain in four agricultural watersheds in the United States. *J Environ Qual.* May 2;37(3):1101-15. Available online at http://www.ncbi.nlm.nih.gov/pubmed/18453431.

  This is yet another publication using some of the same data as those in the prior citation but extending the region to more states. The assumptions and summaries are similar. It documents chemicals collected in rain and attributes them to agricultural uses.

> Chang, F.C., M.F. Simcik, and P.D. Capel. 2011. Occurrence and fate of the herbicide glyphosate and its degradate aminomethylphosphonic acid in the atmosphere. *Environ Toxicol Chem.* Mar;30; (3):548-55. Available online at http://www.ncbi.nlm.nih.gov/pubmed/21128261.

  This is another report on the ambient levels of glyphosate in air and rain. Air and rain samples were collected during two growing seasons in agricultural areas in Mississippi and Iowa. The frequency of glyphosate detection ranged from 60 to 100 percent in both air and rain. The concentrations of glyphosate ranged from <0.01 to 9.1 ng/cubic meter and from <0.1 to 2.5 µg/L in air and rain samples, respectively. The frequency of detection and median and maximum concentrations of glyphosate in air were similar or greater to those of the other high-use herbicides observed in the Mississippi River basin. It was estimated that up to 0.7 percent of the application is removed from the air in rainfall, although there is no metric to determine the initial percentage released. The authors indicated that glyphosate is efficiently removed from the air; it is estimated that an average of 97 percent of the glyphosate in the air is removed by a weekly rainfall ≥ 30 mm. The assumptions and summaries are similar. It documents chemicals in collected rain and attributes it to agricultural uses.

This information in the cited reports is not relevant to the PEIR's analysis or impact determinations because it does not address the specific methods of chemical use by the District in its Service Area, and the commenter does not explain its relevance to any specific analysis or determination in the PEIR.

Additional References

Chang, F-C., M.F. Simcik, and P.D. Capel. 2011. Occurrence and fate of the herbicide glyphosate and its degradate aminomethylphosphonic acid in the atmosphere. *Environ Toxicol Chem.* 30; (3):548-55.

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US Geological Survey (USGS) 2016. Science News. Available online at http://www.usgs.gov/newsroom/article.asp?ID=2909#.VfnIlNVViko.

Vogel, J.R., M.S. Majewski, and P.D. Capel. 2008. Pesticides in rain in four agricultural watersheds in the United States. *J Environ Qual.* May 2;37(3):1101-15. Available online at http://www.ncbi.nlm.nih.gov/pubmed/18453431.

I-Fra2

Comment 2 from Mary Fraser

I want the Directors of the District to approve the No Chemicals option in the Draft PEIR. Here is a copy of a speech I did on why pesticides should be banned along with its references. Please use this as one of my comments. 1

WHY PESTICIDES SHOULD BE BANNED.

9/16/15

Thank you Mr. President, Fellow Toastmasters and Welcome Guests,

I want to share this graphic with you. For those of you who can't read it, it says: It's Raining Roundup. With a picture of a little girl playing in the rain. Underneath it says: Monsanto's Roundup found in 75% of air and rain samples. (1) I find this very disturbing. I would think you would find it disturbing too. Pesticides raining on our heads.

I am the mother of three children and have had the unfortunate experience of having a child in the intensive care unit for 35 days. Since I never, ever want to have that experience again, I've educated myself on health hazards. Today I want to share my findings about pesticides with you. I come from a large family of attorneys, so all of my facts in this speech have been verified. I have a copy of this speech available with references to all the facts that I quote.

This graphic was created from data found in official gov't studies. The United States Geographical Survey has done testing in several states and this is what they have consistently found. 75% of the air and rain samples had Roundup in it. (2)

Let me give you a little background on pesticides.

The word Pesticide means death to pests. It is an umbrella term. Under the umbrella, we have herbicides or death to plants, insecticides or death to animals and fungicides or death to fungi. Many people think that a more apt term for pesticide is ecocide. Death to the environment.

Now imagine that this jar is a can of pesticide. Inside this jar, there is the main ingredient or what is technically called the 'active principle'. This is the chemical that the EPA requires manufacturer's to do testing on. The manufacturer's do the testing. The EPA only reviews the tests. Along with the active principle, there are inerts and/or adjuvants added to the formula. Under EPA rules, the inerts and adjuvants do not need to be tested. They do not need to be

2

I-Fra2

disclosed to the public as they can be considered to be trade secrets or proprietary business information. So what you have, is a can of chemicals of completely unknown toxicity, untested and undisclosed. (3) Now many of you have gone to your doctor and when he wants to write you a prescription, he always asks about other drugs you are taking. He doesn't want any unforeseen chemical reactions. I guess the EPA didn't get that memo. This is the dirty little secret of pesticides and one of the dirty little secrets about the EPA. Now, after the manufacturer has created this pesticide of unknown toxicity, they are often patented. Once patented, no one can do research on the formula without the patent holders permission. Fat chance.

Let me go back to the graphic. " It's Raining Roundup." The active principle or main ingredient in Roundup is glyphosate. The World Health Organization has just declared that glyphosate causes cancer in animals. (4) They declared it to be a 'probable human carcinogen' only because they could not find enough enough scientific studies on humans and glyphosate. It is unethical to try to induce cancer in humans and the few studies they had just didn't have enough data.

The patent has run out on Roundup and a group of independent scientists did studies on it. What they found was that Roundup was 1000x more toxic than its main ingredient glyphosate. 1000x time more toxic. (5) Roundup is the most widely used pesticide in this country. We use millions of pounds of it per year. (6) It's what genetically modified crops like corn, soy , canola, sugar beets, alfalfa and cotton are designed to withstand heavy doses of. (7) 80% of all processed foods contain GMO ingredients. (8) It's allowed on 160 different food crops in this country. (9) Farmers spray it on many crops right before harvest to eliminate weeds and dry out the crops. Right before harvest. So many of us are now gluten intolerant. Well, Roundup is oftentimes sprayed on wheat right before harvest. You're not gluten intolerant. You're being poisoned. (9) And no one tests for residues of Roundup on our food. That's another dirty little secret about the EPA. (10) We test for other pesticides but not Roundup.

So what are the public health consequences of all this toxicity? According to the American Cancer Society, the official rate of cancer in 2015 is now 1 in 2. That's for men. 1 in 2. For women its 1 in 3. (11) And that is just cancer. Roundup has been linked to 32 other chronic diseases (12) and has been found in breast milk, urine (13) and now it's raining Roundup.

So what can you do? If you have Roundup at home, carefully take it to the hazardous waste facility. Eat only organic food and you will avoid about 80% of pesticides. This is particularly important for children as they eat more per lb. of body weight than adults do and their bodies do not have the same capacity to detox pesticides as adults do. (14)

2

I-Fra2

And exercise your democratic rights. The Marin Co Board of Supervisors has the issue of banning pesticides on its agenda on Oct. 6th. Let them know what you think. The CA EPA has opened comments about adding Roundup to its list of Prop. 65 chemicals and our Mosquito abatement program is proposing to use Roundup. I have notices on all of these actions and I have information on eating organic food .

Let me close with another graphic. This is a quote from Dr. Don Huber, a professor emeritus of Plant Pathology, Purdue University.

"Future generations will judge us- not on how many millions of tons of pesticides we sprayed, but on how willing we were- how perfectly willing we were, to sacrifice our children". (16)

2

Thank you. You have my permission to share this speech with anyone or to contact me if you wish a copy of this speech in electronic form.

Mary Fraser

[redacted]

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I-Fra2

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   BioMed Research International

   Volume 2014, Article ID 179691, 8 pages

Major Pesticides Are More Toxic to Human Cells Than Their Declared Active Principles

RobinMesnage,[1] Nicolas Defarge,[1] Joël Spiroux de Vendômois,[2] and Gilles-Eric Séralini[1]
http://dx.doi.org/10.1155/2014/179691

https://d3n8a8pro7vhmx.cloudfront.net/yesmaam/pages/680/attachments/original/1407922431/2012._Mesnage_et_al._Ethoxylated_adjuvants_of_glyphosate-based_herbicides_are_active_principles_of_human_cell_toxicity.pdf?1407922431

Ethoxylated adjuvants of glyphosate based herbicides are active principles of human cell toxicity.

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Potential toxic effects of glyphosate and its commercial formulations below regulatory limits

7. https://d3n8a8pro7vhmx.cloudfront.net/ncap/pages/26/attachments/original/1428423381/glyphosate.pdf?1428423381 **JOURNAL OF PESTICIDE REFORM/ WINTER 2004 • VOL. 24, NO. 4 HERBICIDE FACTSHEET**

I-Fra2

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   Glyphosate, pathways to modern diseases II: Celiac sprue and gluten intolerance

   Anthony SAMSEL 1 and Stephanie SENEFF 2 1 Independent Scientist and Consultant, Deerfield, NH 03037, USA 2 Computer Science and Artificial Intelligence Laboratory, MIT, Cambridge, MA, USA ITX060413R01 • Received: 24 September 2013 • Revised: 10 November 2013 • Accepted: 12 November 2013

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5. **American Cancer Society publication: Cancer Facts & Figures 2015, page 14.**

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   Journal of Organic Systems, 9(2), 2014 ORIGINAL PAPER

   Genetically engineered crops, glyphosate and the deterioration of health in the United States of America

   Nancy L. Swanson1 , Andre Leu2 *, Jon Abrahamson3 and Bradley Wallet4

I-Fra2

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   Conducted by Moms Across America and Sustainable Pulse

   April 7, 2014.

   Zen Honeycutt, Moms Across America, Henry Rowlands, Sustainable Pulse

8. Pesticide Action Network North America, **"A Generation in Jeopardy, How pesticides are undermining our children's health & intelligence".**
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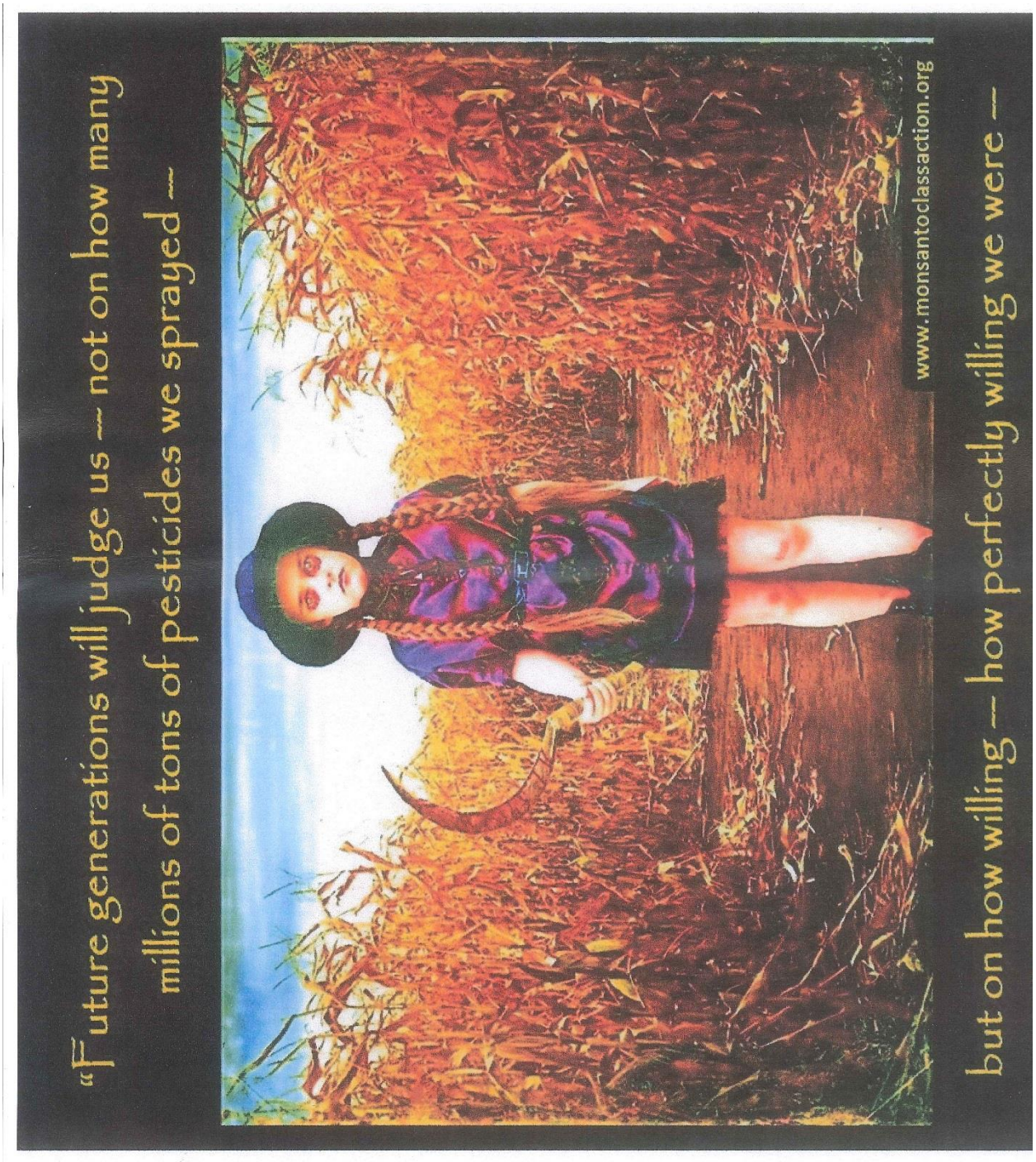
Sincerely,

Mary Fraser

[redacted]


"Future generations will judge us — not on how many
millions of tons of pesticides we sprayed —
but on how willing — how perfectly willing we were —
www.monsantoclassaction.org

Comment Letter I-Fra2 — Fraser, Mary

Response 1

The No Chemical Program was reviewed in Section 15.4.2 of the Draft PEIR. This comment will be considered by the District's Board of Trustees in its consideration whether to approve the Program as proposed, or with modifications.

Response 2

The copy provided of Ms. Fraser's speech to Toastmasters shows that is about why she feels that pesticides should be banned. It does not address the District's PEIR. Comments are noted and considered, and no further analysis of references for a speech to others is required. The commenter does not explain how the references on the general subject of glyphosate relate to the PEIR analysis.

See Responses I-Fra3-3 through I-Fra3-6 on the subject of glyphosate. Responses to Ms. Fraser's subsequent written comments cover the issues she has raised and the studies she has provided as attachments or as links to websites and are not duplicated herein.

I-Fra3

Comment 3 from Mary Fraser

Dear Marin Sonoma Mosquito and Vector Control,
I am writing to inform you of my concerns about your Draft PEIR. My concerns are many and I will be sending you multiple emails.
1. You have given the public inadequate time and notice of these hearings and their content. You published a 'legal notice' only on August 28th and expect the public to be able to read and prepare comments no later than Oct. 2, 2015 on a document that is over 500 pages. You made the document available in libraries in CD form. Most libraries have reservation systems in order to use a computer, time is limited to one hour per reservation and to print out any pages is a ten cent fee per page. All of this combined makes for great difficulty in reading and analyzing your Draft PEIR. I am requesting that you extend the official notification period to at least 120 days, that you take out 1/4 page 'display' ads in newspapers and that you send notifications of the Draft PEIR to multiple NGO's and non-profits. I also want you to supply copies of the Draft PEIR to interested individuals at no charge. I have not had adequate time to analyze your entire PEIR. 1

2. I attended your Public Hearing on Sept. 12, 2015 and watched a power point presentation that was misleading. The presentation stated that you use chemicals approved for organic food production and that you consulted beekeepers. During a very brief review of the Draft PEIR in my one hour computer time allotment at the public library, I found that you propose to use glyphosate. That is a chemical pesticide that is not allowed in organic food production. The World Health Organization thru its research arm, The International Agency for Research on Cancer has declared glyphosate to be carcinogenic to animals, giving glyphosate a 1 rating for animals and a 2A rating for humans. 2

In reviewing the Draft PEIR I noted that the information on glyphosate is inaccurate in the following ways: a. "Section 4.6.2.3 Human Toxicity. The shikimic acid pathway is specific to plants and some microorganisms; therefore, glyphosate is thought to have very low toxicity to mammals (USEPA 1993)" This is old information. Dr. Stephanie Seneff, MIT and Anthony Samsel have found that the shikimic pathway is present in bacteria in the human gut. Here is their peer reviewed, published paper.
http://people.csail.mit.edu/seneff/Entropy/entropy-15-01416.pdf
Dr. Seneff and Anthony Samsel have published numerous other articles about glyphosate. Here are other articles:
http://people.csail.mit.edu/seneff/ITX_2013_06_04_Seneff.pdf
http://surgicalneurologyint.com/surgicalint_articles/glyphosate-pathways-to-modern-diseases-iii-manganese-neurological-diseases-and-associated-pathologies/ 3

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http://people.csail.mit.edu/seneff/Hoy_wildlife_2015.pdf
http://people.csail.mit.edu/seneff/glyphosate/Chen_I_wan_Reference_info_glyphosate_June18_2014.pdf

3

Glyphosate is rarely used alone. It is almost always used in combination with inerts and adjuvants. A team of independent scientists did studies on the complete formulation of Roundup, which is the most widely used pesticide that has glyphosate as its main ingredient. The testing found that the complete formulations had toxicity levels that were up to 1000x more toxic. Here are two of the studies:

Major Pesticides Are More Toxic to Human Cells Than Their Declared Active Principles

RobinMesnage,[1] Nicolas Defarge,[1] Joël Spiroux de Vendômois,[2] and Gilles-Eric Séralini[1]
http://dx.doi.org/10.1155/2014/179691

https://d3n8a8pro7vhmx.cloudfront.net/yesmaam/pages/680/attachments/original/1407922431/2012._Mesnage_et_al._Ethoxylated_adjuvants_of_glyphosate-based_herbicides_are_active_principles_of_human_cell_toxicity.pdf?1407922431

Ethoxylated adjuvants of glyphosate based herbicides are active principles of human cell toxicity.

4

In Section 4.6.2.3 it is stated " There is currently no published scientific. evidence indicating that glyphosate is carcinogenic or mutagenic". I am attaching a copy of the WHO report that disputes this and that labels glyphosate as carcinogenic to animals and a probable human carcinogen. I don't understand why this report has not been included in the Draft PEIR. The initial release was in March 2015 and the entire monograph was released in July 2015. There have been numerous media reports about the WHO finding!
In Section 4.6.2.1 there is a table of the degradation of glyphosate. Monsanto, the manufacturer of glyphosate has been sued by both the State of New York and the county of France over falsely advertising that their product, Roundup, (which has glyphosate as its active principle) is biodegradable. The county of France won their case, even though it was appealed to the highest court in France and the State of New York settled the case with Monsanto. The degradation of glyphosate is dependent on the chemical nature of the environment it is in. In some cases it can take up to 20 years or more to biodegrade.

5

All of my referenced attachments should be included in my comments.

6

Please do not use glyphosate. I want the Directors of the District to approve the No Chemical option that is proposed in your Draft PEIR.
Mary Fraser
[redacted]

7

Entropy **2013**, *15*, 1416-1463; doi:10.3390/e15041416

OPEN ACCESS

entropy
ISSN 1099-4300
www.mdpi.com/journal/entropy

Review

Glyphosate's Suppression of Cytochrome P450 Enzymes and Amino Acid Biosynthesis by the Gut Microbiome: Pathways to Modern Diseases

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[2] Computer Science and Artificial Intelligence Laboratory, MIT, Cambridge, MA 02139, USA

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Tel.: +1-617-253-0451; Fax: +1-617-258-8642.

Received: 15 January 2013; in revised form: 10 April 2013 / Accepted: 10 April 2013 / Published: 18 April 2013

Abstract: Glyphosate, the active ingredient in Roundup®, is the most popular herbicide used worldwide. The industry asserts it is minimally toxic to humans, but here we argue otherwise. Residues are found in the main foods of the Western diet, comprised primarily of sugar, corn, soy and wheat. Glyphosate's inhibition of cytochrome P450 (CYP) enzymes is an overlooked component of its toxicity to mammals. CYP enzymes play crucial roles in biology, one of which is to detoxify xenobiotics. Thus, glyphosate enhances the damaging effects of other food borne chemical residues and environmental toxins. Negative impact on the body is insidious and manifests slowly over time as inflammation damages cellular systems throughout the body. Here, we show how interference with CYP enzymes acts synergistically with disruption of the biosynthesis of aromatic amino acids by gut bacteria, as well as impairment in serum sulfate transport. Consequences are most of the diseases and conditions associated with a Western diet, which include gastrointestinal disorders, obesity, diabetes, heart disease, depression, autism, infertility, cancer and Alzheimer's disease. We explain the documented effects of glyphosate and its ability to induce disease, and we show that glyphosate is the "textbook example" of exogenous semiotic entropy: the disruption of homeostasis by environmental toxins.

Keywords: glyphosate; cytochrome P450; eNOS; obesity; cardiovascular disease; cancer; colitis; shikimate pathway; gut microbiome; tryptophan; tyrosine; phenylalanine; methionine; serotonin; Alzheimer's disease; Parkinson's disease; autism; depression

PACS Codes: 87.19.xj; 87.19.xr; 87.19.xv; 87.19.xw; 87.19.xb; 87.19.xp

1. Introduction

The foodstuffs of the Western diet, primarily grown by industrial agriculture, are increasingly being produced using a two-part system of engineered plant seeds and toxic chemical application. Novel bacterial genes are incorporated through genetic engineering, and toxic chemical residues are readily taken up by the engineered plants. Research indicates that the new bacterial RNA and DNA present in genetically engineered plants, providing chemical herbicide resistance and other traits, have not yet fully understood biological effects. This paper however, will only examine the effects of the chemical glyphosate, the most popular herbicide on the planet.

Glyphosate (N-phosphonomethylglycine), the active ingredient in the herbicide Roundup®, is the main herbicide in use today in the United States, and increasingly throughout the World, in agriculture and in lawn maintenance, especially now that the patent has expired. 80% of genetically modified crops, particularly corn, soy, canola, cotton, sugar beets and most recently alfalfa, are specifically targeted towards the introduction of genes resistant to glyphosate, the so-called "Roundup Ready® feature" In humans, only small amounts (~2%) of ingested glyphosate are metabolized to aminomethylphosphonic acid (AMPA), and the rest enters the blood stream and is eventually eliminated through the urine [1]. Studies have shown sharp increases in glyphosate contamination in streams in the Midwestern United States following the mid 1990s, pointing to its increasing role as the herbicide of choice in agriculture [2]. A now common practice of crop desiccation through herbicide administration shortly before the harvest assures an increased glyphosate presence in food sources as well [3–5]. The industry asserts that glyphosate is nearly nontoxic to mammals [6,7], and therefore it is not a problem if glyphosate is ingested in food sources. Acutely, it is claimed to be less toxic than aspirin [1,6]. As a consequence, measurement of its presence in food is practically nonexistent. A vocal minority of experts believes that glyphosate may instead be much more toxic than is claimed, although the effects are only apparent after a considerable time lapse. Thus, while short-term studies in rodents have shown no apparent toxicity [8], studies involving life-long exposure in rodents have demonstrated liver and kidney dysfunction and a greatly increased risk of cancer, with shortened lifespan [9].

Glyphosate's claimed mechanism of action in plants is the disruption of the shikimate pathway, which is involved with the synthesis of the essential aromatic amino acids, phenylalanine, tyrosine, and tryptophan [10]. The currently accepted dogma is that glyphosate is not harmful to humans or to any mammals because the shikimate pathway is absent in all animals. However, this pathway *is* present in gut bacteria, which play an important and heretofore largely overlooked role in human physiology [11–14] through an integrated biosemiotic relationship with the human host. In addition to aiding digestion, the gut microbiota synthesize vitamins, detoxify xenobiotics, and participitate in immune system homeostasis and gastrointestinal tract permeability [14]. Furthermore, dietary factors modulate the microbial composition of the gut [15]. The incidence of inflammatory bowel diseases such as juvenile onset Crohn's disease has increased substantially in the last decade in Western Europe [16] and the

United States [17]. It is reasonable to suspect that glyphosate's impact on gut bacteria may be contributing to these diseases and conditions.

However, the fact that female rats are highly susceptible to mammary tumors following chronic exposure to glyphosate [9] suggests that there may be something else going on. Our systematic search of the literature has led us to the realization that many of the health problems that appear to be associated with a Western diet could be explained by biological disruptions that have already been attributed to glyphosate. These include digestive issues, obesity, autism, Alzheimer's disease, depression, Parkinson's disease, liver diseases, and cancer, among others. While many other environmental toxins obviously also contribute to these diseases and conditions, we believe that glyphosate may be the most significant environmental toxin, mainly because it is pervasive and it is often handled carelessly due to its perceived nontoxicity. In this paper, we will develop the argument that the recent alarming increase in all of these health issues can be traced back to a combination of gut dysbiosis, impaired sulfate transport, and suppression of the activity of the various members of the cytochrome P450 (CYP) family of enzymes. We have found clear evidence that glyphosate disrupts gut bacteria and suppresses the CYP enzyme class. The connection to sulfate transport is more indirect, but justifiable from basic principles of biophysics.

In the remainder of this paper, we will first provide evidence from the literature that explains some of the ways in which glyphosate adversely affects plants, microbes, amphibians and mammals. Section 3 will discuss the role that gut dysbiosis, arguably resulting from glyphosate exposure, plays in inflammatory bowel disease and its relationship to autism. Section 4 argues that the excess synthesis of phenolic compounds associated with glyphosate exposure represents a strategy to compensate for impairments in the transport of free sulfate. Section 5 will provide evidence that glyphosate inhibits CYP enzymes. Section 6 explains how obesity can arise from depletion of serum tryptophan due to its sequestering by macrophages responding to inflammation. Section 7 shows how extreme tryptophan depletion can lead to impaired nutrient absorption and anorexia nervosa. Section 8 provides a brief review of all the roles played by CYP enzymes in metabolism. Section 9 discusses a likely consequence to glyphosate's disruption of the CYP-analog enzyme, endothelial nitric oxide synthase (eNOS). Section 10 shows how glyphosate's effects could plausibly lead to brain-related disorders such as autism, dementia, depression, and Parkinson's disease. Section 11 mentions several other health factors that can potentially be linked to glyphosate, including reproductive issues and cancer. Section 12 discusses the available evidence that glyphosate is contaminating our food supplies, especially in recent years. Following a discussion section, we sum up our findings with a brief conclusion.

2. Glyphosate's Pathological Effects: Controlled Studies

It is well established that glyphosate, a member of the general class of organophosphates, inhibits the enzyme 5-enolpyruvylshikimic acid-3-phosphate synthase (EPSP synthase), the rate-limiting step in the synthesis of aromatic amino acids in the shikimate pathway in plants [18]. This pathway, while not present in mammals, is present in algae, Archaea, bacteria, fungi, and prokaryotes, and unicellular eukaryotic organisms [19]. Indeed, corn and soy crops have both been shown to accumulate excess shikimate in response to glyphosate exposure [20]. However, a study comparing glyphosate-tolerant and glyphosate-sensitive carrot cell lines identified several pathologies beyond the inhibition of

aromatic amino acids following glyphosate exposure [21]. It was determined that, in addition to abnormally low levels of tryptophan, phenylalanine and tyrosine, the glyphosate-sensitive cells also had 50 to 65% reduced levels of serine, glycine and methionine. The reduction in methionine can have many adverse consequences, as methionine is an essential sulfur-containing amino acid that has to be supplied from the diet. In addition, there was evidence of excess ammonia in the glyphosate-sensitive but not the glyphosate-adapted cells. Both cell types readily absorbed glyphosate from the medium, with a rapid linear uptake observed during the first eight hours following exposure. This demonstrates that glyphosate would be present in food sources derived from glyphosate-exposed plants.

The excess ammonia observed in glyphosate-treated plants could be due to increased activity of phenylalanine ammonia lyase (PAL), an enzyme found in plants, animals, and microbes, that catalyzes the reaction that converts phenylalanine to trans-cinnamate, releasing ammonia [22]. In studies on transgenic tobacco, it was demonstrated that a decrease in the aromatic amino acid pool sizes (a direct consequence of glyphosate exposure) results in an enhancement of metabolic flux through the shikimate pathway, which leads to a rise in PAL activity as well as a doubling of the levels of chlorogenic acid, a polyphenolic compound related to cinnamate [23]. It has been proposed that glyphosate achieves part if not all of its growth-retardation effects on plants through induction of PAL activity [24]. The growth disruption could be due either to toxicity of the derived phenolic compounds [25] or to direct toxicity of the ammonia. A study of olive trees showed that there is a direct relationship between the total phenol concentration and PAL activity, suggesting that PAL is a major producer of phenolic compounds [26]. Glyphosate has been shown to increase PAL activity in both soybean seedlings [27] and in corn [28].

Under stress-inducing environments, the secondary metabolites derived from certain protein synthesis pathways become disproportionately important, and enzyme regulation induces dramatic shifts in the production of the amino acids *versus* the secondary metabolites. A study comparing glyphosate exposure with aromatic protein deprivation in plants found several effects in common, but there was a striking anomaly for glyphosate in that it caused a 20-fold increase in the synthesis of the rate-limiting enzyme for a pathway leading to flavonoid synthesis, as a side branch of the tryptophan synthesis pathway [29]. More generally, there is substantial evidence that glyphosate induces the synthesis of monophenolic compounds as well as the polyphenolic flavonoids, in both plants [30] and microbes [31], with concurrent depletion of aromatic amino acid supplies. When carrots are exposed to high doses of glyphosate, they produce significant amounts of various phenolic compounds as well as shikimic acid [32]. The significance of this will become apparent later on in Section 4 on sulfate transport. Elevated amounts of shikimate-derived benzoic acids such as protocatechuate and gallate are also found in plants exposed to glyphosate [29]. Strains of nitrogen-fixing bacteria in the soil produce hydroxybenzoic acids in the presence of glyphosate [31]. This digression towards the competing pathways to produce phenolic and benzoic acid compounds may well explain the suppression of aromatic amino acid synthesis by glyphosate.

Even Roundup Ready® crops typically experience slowed growth following glyphosate applications, and this has been attributed to glyphosate's role as a chelator of micronutrients. In early work, glyphosate was shown to interfere with the uptake of the divalent cations, calcium and magnesium, through soybean roots [33]. Glyphosate severely reduced calcium content in the mitochondria of both root and leaf cells. Since magnesium was also affected, but potassium was not, the authors

suggested that this property might hold for all divalent cations. More recent greenhouse experiments demonstrated that glyphosate application to the root system decreased the levels of calcium, magnesium, iron and manganese in the seeds of the plants [34]. It was proposed that glyphosate binds to and immobilizes all of these divalent micronutrients, impairing their uptake by the plant. These glyphosate-induced deficiencies would carry over to the food supply, leading to deficiencies in these nutrients in humans who consume foods derived from glyphosate-exposed crops.

Evidence of disruption of gut bacteria by glyphosate is available for both cattle and poultry. It has recently been proposed that glyphosate may be a significant factor in the observed increased risk to *Clostridium botulinum* infection in cattle in Germany over the past ten to fifteen years [35]. Glyphosate's demonstrated toxicity to *Enterococcus* spp. leads to an imbalance in the gut favoring overgrowth of the toxic *Clostridium* species. Glyphosate has been shown to have remarkable adverse effects on the gut biota in poultry [36], by reducing the number of beneficial bacteria and increasing the number of pathogenic bacteria in the gut. Highly pathogenic strains of *Salmonella* and *Clostridium* were found to be highly resistant to glyphosate, whereas beneficial bacteria such as *Enterococcus*, *Bacillus* and *Lactobacillus* were found to be especially susceptible. Due to the antagonistic effect of the common beneficial bacterium *Enterococcus* spp. on *Clostridia*, toxicity of glyphosate to *E*. spp could lead to overgrowth of *Clostridia* and resulting pathologies.

Pseudomonas spp. is an opportunistic pathogen and an antibiotic-resistant Gram-negative bacterium that has been shown to be able to break down glyphosate to produce usable phosphate and carbon for amino acid synthesis, but a toxic by-product of the reaction is formaldehyde [37], which is neurotoxic, and low levels of formaldehyde can induce amyloid-like misfolding of tau protein in neurons, forming protein aggregates similar to those observed in association with Alzheimer's disease [38].

A recent genome-wide study of the effect of glyphosate on *E. coli* revealed metabolic starvation, energy drain, and other effects involving genes that are poorly understood [39], in addition to suppression of the shikimate pathway. For example, half of the eight genes encoding ATP synthase were downregulated, suggesting an impairment in mitochondrial ATP synthesis. At the same time, genes involved in importing sugars were upregulated, which suggests a switch to anaerobic fermentation, producing pyruvate (a much less efficient solution) rather than oxidizing glucose for full breakdown to carbon dioxide and water. A switch to anaerobic metabolism is also suggested from a study showing that, in soil treated with glyphosate, the total count of fungi was significantly increased, while oxygen consumption was significantly inhibited [40].

Research conducted by exposing an outdoor aquatic mesocosm (approximating natural conditions) to two pesticides and two herbicides revealed a unique effect (among the four toxins studied) of the herbicide, glyphosate, to destroy tadpoles. Following only a two-week exposure period, two species of tadpoles were completely eliminated and a third one was nearly exterminated, resulting in a 70% decline in the species richness of tadpoles [41]. Other experiments on bullfrog tadpoles showed that prior glyphosate exposure reduced the survival rates of tadpoles exposed to the fungal pathogen, *Batrachochytrium dendrobatidis* (Bd). [42]. It is thus conceivable that glyphosate may be instrumental in the worldwide decimation of frogs currently taking place [43]. This also suggests that glyphosate disrupts embryonic development, a topic to which we will return later.

An insidious issue with glyphosate is that its toxic effects on mammals take considerable time to be overtly manifested. Studies on Wistar rats exposed to the highest levels of glyphosate allowed in water

for human consumption for 30 or 90 days showed enhanced lipid peroxidation and glutathione peroxidase activity, indicators of oxidative stress [44]. A long-term study conducted on rats showed remarkable pathologies that became apparent only after the three-month period that is usually allotted for toxicity trials. In this experiment, rats were monitored over their entire lifespan, while being fed either genetically modified (GM) or non-GM maize that had been optionally treated with Roundup® [9]. The rats that were chronically exposed to Roundup® developed several pathologies over the course of their lifespan, including large mammary tumors in the females and gastrointestinal, liver and kidney pathologies, especially in the males. The males developed both skin and liver carcinomas. Premature death in the treated male rats was mostly due to severe hepatorenal insufficiencies. Other researchers have shown that oral exposure to glyphosate in drinking water can induce DNA damage to mouse cells drawn from blood and liver [45].

Researchers have discovered that Roundup® is sometimes much more toxic than glyphosate by itself, and this discrepancy can be explained by the fact that Roundup® includes a surfactant which greatly enhances cytotoxic effects of glyphosate [46]. Specifically, the surfactant, TN-20, commonly found in glyphosate-based herbicides, was studied for its effect on glyphosate toxicity to rat cells *in vitro*. The results showed that the combination of the surfactant and glyphosate led to mitochondrial damage, apoptosis, and necrosis, under conditions where neither substance working alone achieved this effect. It was proposed that TN-20 disrupts the integrity of the cellular barrier to glyphosate uptake.

A study on three microorganisms commonly used as starters in dairy technologies demonstrated that Roundup®, but not glyphosate, inhibited microbial growth at lower concentrations than those recommended in agriculture [47]. This result illustrates an amplified effect of glyphosate's toxicity through the adjuvants found in Roundup®. The authors also suggested that a recent loss of microbiodiversity in raw milk may be explained through the same toxic mechanisms.

In humans, a prolonged accidental skin exposure to a glyphosate-surfactant herbicide has been shown to produce local swelling, bullae, and exuding wounds, followed by osteopenia, neurological impairment, and reduced nerve conduction [48]. Similarly oral exposure to glyphosate produces chemical burns and ulceration of the oral cavity [49].

3. Gut Dysbiosis, Autism and Colitis

It is now well established that autism spectrum disorder (ASD) is associated with dysbiosis in the gut [50], and, indeed, this is viewed by many as an important contributor to ASD [51]. An increase in short chain fatty acids and ammonia in the gut has been found in association with autism [52,53]. Since these are by-products of anaerobic fermentation, this suggests an overgrowth of anaerobic bacteria such as *Clostridia*, *Bacteriodetes*, and *Desulfovibrio*. *Clostri*dia have indeed been found in excess in the feces of autistic children [54]. By-products of fermentation by anaerobes, such as phenols, amines, ammonia, and hydrogen sulfide, can be toxic to the large bowel [1,8]. A strong link between autism and hepatic encephalitis has been identified [55], where the key underlying pathology may be excess ammonia in the blood stream. Ammonia plays an important role in the etiology of hepatic encephalopathy associated with both acute and chronic liver dysfunction [56,57]. The source of the ammonia is believed to be intestinal bacteria, including those in both the small and large intestine [58]. Impaired liver function prevents detoxification of ammonia via the urea pathway. Thus, the increased activity of

PAL induced by glyphosate [27,28] could play a role in creating a hyperammonemic environment in the gut and initiating subsequent pathology.

Indeed, there is now evidence that gut microbes can produce ammonia from phenylalanine via PAL [59]. A unique mouse phenotype has recently been identified that is defined by the behavior of its gut bacteria [60], and the authors suggest that this phenotype can be explained through increased metabolism of phenylalanine via the PAL pathway. Furthermore, this unique phenotype is also associated with excess synthesis of p-cresol, via a pathway involved in tyrosine breakdown. These authors go on to propose that the known sulfate deficiency associated with autism [61,62] may be explained by the depletion of sulfate through sulfation of *p*-cresol produced from tyrosine by *Clostridium difficile* in the gut [63,64], in order to detoxify it. As we will explain in the next section, we believe that, in fact, p-cresol and other phenolic compounds are part of the *solution* rather than the *cause*, with respect to impaired sulfate transport.

C. difficile is a well-established causal factor in colitis [65]. The incidence of *C. difficile*-associated disease has increased significantly in North America in recent years, and research into the association of this increase with inflammatory bowel disease has borne fruit [66]. In an observational study involving patients in a hospital in Wisconsin between 2000 and 2005, it was shown that *C. difficile* infection was almost nonexistent in patients with inflammatory bowel disease prior to 2003, but the rate grew from 4% to 7% to 16% in 2003, 2004, and 2005. One hypothesis presented was antibiotic use disrupting the beneficial gut bacteria, but it is conceivable that increased exposure to glyphosate is contributing to this increase.

A higher level of *p*-cresol in the urine has been associated with lower residual sulfonation [67] and with autism [68]. *p*-Cresol, formed via anaerobic metabolism of tyrosine by bacteria such as *C. difficile* [64], is a highly toxic carcinogen, which also causes adverse effects on the central nervous system, the cardiovascular system, lungs, kidney and liver [69]. A recent paper found that formula-fed infants had an overrepresentation of *C. difficile* in the gut bacteria [70]. In a case-control study, children with autism were found to be significantly more likely to have been formula-fed rather than breast-fed [71]. The study did not distinguish between organic and non-organic formula, but one can surmise that non-organic soy formula might be contaminated with glyphosate, and this could be a contributing factor to both the autism and the *C. difficile*. Urinary bacterial metabolites of phenylalanine, such as benzoic and phenylacetic acids, and of tyrosine (*p*-hydroxybenzoic acid and *p*-hydroxyphenylacetic acid) have been found to be elevated in association with several different diseases reflecting impaired intestinal resorption, including coeliac disease, cystic fibrosis, and unclassified diarrhoea [72]. It was proposed that these metabolites were produced by the gut bacteria. High concentrations of an abnormal phenylalanine metabolite have been found in the urine of people with autism and schizophrenia, up to 300x normal adult values, which is likely due to multiple species of anaerobic bacteria in the *Clostridium* genus [73]. Others have detected abnormally high concentrations of hippurate in the urine in association with autism [74]. Hippurate is a liver metabolite of benzoic acid [75]. Thus a variety of different compounds representing a deflection of aromatic amino acid synthesis towards oxidized benzene derivatives have been found in association with various digestive disorders and neurological disorders.

Studies have convincingly shown an inflammatory mucosal immunopathology in children with regressive autism characterized by infiltration of intestinal epithelial lymphocytes [76]. The infiltration of immune system cells like lymyphocytes and eosinophils is a direct response to the impaired barrier

function. As will be seen in the next section, we propose that this dysbiosis is caused principally by impaired sulfate supply to the mucosa, and that the toxic phenolic compounds both assist in correcting this deficiency and induce inflammatory responses due to their oxidizing effects.

4. Sulfate Transport Impairment and Phenol Synthesis

Autism is a disorder involving impaired social skills and neurodevelopmental delay that has reached epidemic proportions in recent years, with one in 50 children born in the United States today now classified on the autism spectrum, according to the U.S. Centers for Disease Control and Prevention. Impaired sulfur oxidation and low levels of serum sulfate have been established in association with autism since 1990, as evidenced by the following quote from [77]: “These results indicate that there may be a fault either in manufacture of sulphate or that sulphate is being used up dramatically on an unknown toxic substance these children may be producing” (p. 198).

In this section, we develop a novel hypothesis for the effect of glyphosate on aromatic amino acids in plants and microbes. Our arguments depend upon the observation that glyphosate, a short carbon-nitrogen chain with a carbonyl group and a phosphate group, is a strong anionic kosmotrope, since both carbonate and phosphate have this property. Sulfate is also a kosmotrope, whereas nitrate is a chaotrope. Kosmotropes and chaotropes represent opposite extremes on the Hofmeister series [78,79], where kosmotropes tend to structure the water surrounding them and to desolubilize proteins, whereas chaotropes destructure the water and solubilize proteins. Studies on fatalities due to acute over-exposure to glyphosate reveal hemodynamic disturbances, including intravascular disseminated coagulation (DIC) and multiple organ failure, associated with high serum concentrations of glyphosate (over 800 mg/L) [80]. We suspect this has to do with glyphosate's effect as a potent kosmotrope, causing a "salting out" of blood proteins and resultant coagulation and a “no-flow” situation [81].

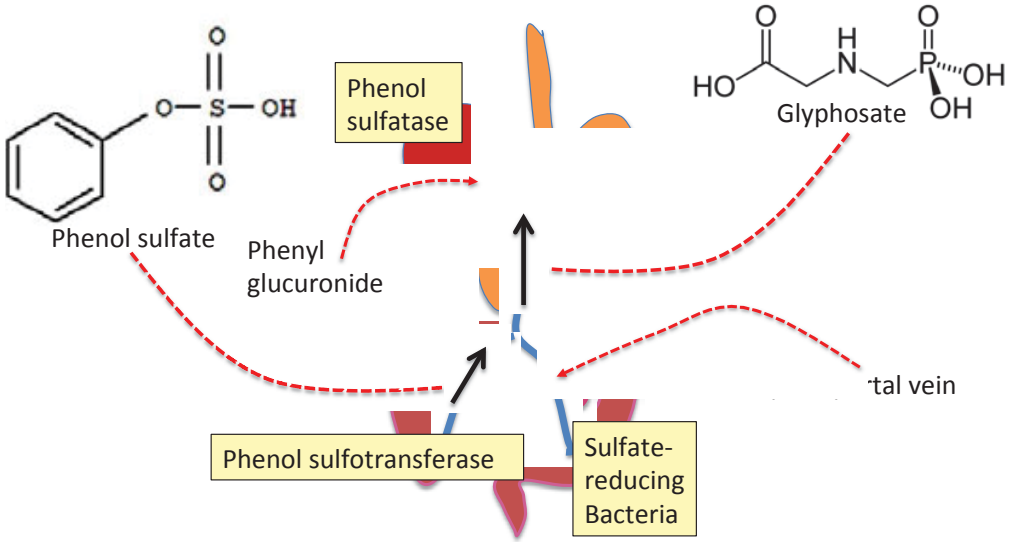
Molecules with a carbon ring and an available attachment site for sulfate (*e.g.*, phenolic compounds) are attractive for the purpose of transporting sulfate through the bloodstream when the kosmotropic load is elevated. Phenolic compounds like *p*-cresol can be readily sulfated in the gut, and this provides an opportunity to transport sulfate through the hepatic portal vein in the presence of glyphosate. The ring supports a charge distribution that diffuses the negative charge and suppresses the water-structuring properties of sulfate, thus preventing the vascular disturbances. A single phenol can perform this feat multiple times, as the sulfate can be attached to the phenol in the colon via a phenol sulfotransferase, and the liver utilizes sulfatases and sulfotransferases to transfer the sulfate moiety from the phenol to an available substrate, typically a xenobiotic or a sterol [82]. Thus, phenols could be responsible for supplying the sulfate critically needed to detoxify xenobiotics and bile acids and to produce various sterol sulfates, as well as supplying sulfate to the pancreas to be incorporated into mucopolysaccharides being released into the gut along with proteases by acinar cells [83].

In this scenario, the glyphosate itself, due to its kosmotropic properties, is disrupting the transport of free sulfate, and therefore the aromatic amino acids are oxidized into various phenolic compounds in order to compensate for this problem. Unfortunately, once they are unsulfated, the phenols become toxic, as they will react destructively with phospholipids and DNA through one-electron transfer [84].

Although flavonoids are generally considered to be beneficial to health, the biological mechanisms behind their benefit are not yet established. In [85], it is stated that “the potential role of microbial

metabolism in the gastrointestinal tract is often overlooked". These authors propose that monophenolic derivatives are likely produced through ring fission of flavonoids by the gut microflora in the colon. Thus, flavonoids can promote sulfate transport to the liver via this process. Furthermore, flavonoids themselves can be both glucuronylated and sulfated [85,86], especially at the 4'-OH position [87], so they could serve directly as sulfate transporters without being broken down. In fact, we hypothesize that their role in sulfate transport is the reason for their abundant synthesis in plants in the presence of glyphosate at the expense of tryptophan [29]. Since they are less toxic than monophenols, they become attractive for sulfate transport in the presence of glyphosate.

Figure 1. Schematic of cyclical process that could be utilized to transport sulfate from the gut to the liver in the face of glyphosate contamination in the hepatic portal vein. Phenolic compounds derived from aromatic amino acids would be cycled back and forth between the gut and the liver, sulfated during transport from the gut to the liver and glucuronylated during transport back from the liver to the gut. Ultimately, a sulfate reducing bacterium could metabolize the phenol, consuming sulfate.



The fact that glyphosate suppresses both alkaline and acid phosphatase activity in *in vitro* assays [88] as well as extracellular alkaline phosphatase synthesis in algae [89] suggests that phosphate faces the same problem as sulfate in plants, in the presence of glyphosate, and hence enzymatic activity that produces free phosphate is suppressed. It is interesting to note that autism is associated with elevated serum levels of pyridoxal phosphate (vitamin B_6) even in the absence of supplements [90]. Despite this, supplemental B6 has been shown to alleviate symptoms of autism [91,92]. We hypothesize that vitamin B6 is exploited to transport phosphate safely in the presence of glyphosate. The pyridoxal ring distributes the negative charge on the phosphate anion in the same way that phenols distribute the charge on sulfate, thus allowing phosphate to be transported in a non-kosmotropic form.

Glyphosate's kosmotropic effects can be counteracted through buffering of chaotropes in the blood, and this could be a factor in the increased levels of both ammonia [93] and various oxides of nitrogen, including nitric oxide, nitrite, and nitrate [94–96] observed in association with autism.

Thus, autism is associated with dysbiosis in the gut [50,51], along with impaired sulfate metabolism and a significantly reduced level of free sulfate in the blood stream (only one-third of the normal level) [63,97–101], excess production of nitric oxide [94–96], overgrowth of phenol-producing bacteria like C. difficile [101], and increased urinary levels of the toxic phenol, *p*-cresol [68]. Autism is also associated with a decreased ability to sulfate and hence detoxify acetaminophen, which aligns with insufficient sulfate bioavailability. A genetic defect in the phenol sulfotransferase gene is associated with autism [77]: this enzyme becomes more essential in the context of glyphosate contamination. All of these observations can potentially be explained by the effects of glyphosate on the gut bacteria and on the blood stream.

Both colitis and Crohn's disease are associated with sulfate depletion in the gut [102], which could be caused by the impaired sulfate transport problem induced by glyphosate exposure. An overgrowth of the sulfur-reducing bacterium, Desulfovibrio, has been found in association with autism [103]. Sulfate-reducing bacteria can utilize aliphatic and aromatic hydrocarbons as electron donors, and therefore they can play an important role in detoxifying toxic phenolic compounds [104–108]. Thus, the presence of *Desulfovibrio* in the gut may serve a dual purpose by metabolizing phenolic compounds while also disposing of free sulfate, which could be problematic if allowed to enter the blood stream in the presence of glyphosate. Thus, we hypothesize that, in the context of glyphosate in the vasculature, aromatic amino acids are diverted into phenolic compounds which can safely transport sulfate from the gut to the liver. The liver can then transfer the sulfate to another metabolite, such as a steroid, and then ship the phenol back to the digestive system for another round via the bile acids following glucuronidation [108]. Possibly after multiple rounds, the phenol is finally metabolized by a sulfate-reducing bacterium in the colon. This idea is schematized in Figure 1.

5. Evidence that Glyphosate Inhibits CYP Enzymes

The evidence that glyphosate inhibits CYP enzymes comes from several directions. There are studies showing inhibition of aromatase, a CYP enzyme that converts testosterone to estrogen, and studies showing enhancement of retinoic acid, which could be achieved by suppressing the CYP enzyme involved in its catabolism. Finally, there are studies that directly show inhibition of detoxifying CYP enzymes in both plants and animals.

Two studies point to a disruption of aromatase activity [109,110]. In [109], as little as 10 ppm. of glyphosate disrupted aromatase activity in human liver HepG2 cells, a well-established cell line to study xenobiotic toxicity. In [110], it was shown that aromatase activity is disrupted in human placental cells at a concentration 100 times lower than that recommended in agricultural use. Furthermore, even small amounts of the adjuvants present in Roundup® could substantially enhance this effect of glyphosate, probably by enhancing the ease with which it gains access to the membrane-bound protein. In experiments with oyster larvae, Roundup® was found to be toxic at less than 1/20 the concentration of glyphosate needed to induce toxicity, thus exhibiting the enormous enhancing effect of Roundup®'s adjuvants [111].

Retinoic acid plays a key role in embryonic development, where its tightly-regulated concentration levels impact developmental stages [112]. Due to reports of neural defects and craniofacial malformations in children born in regions where glyphosate-based herbicides are used, a group of

researchers investigated the effects of low doses of glyphosate (1/5,000 dilutions of a commercial glyphosate-based herbicide) in development of African clawed frog embryos and chick embryos [113]. The treated embryos were highly abnormal: the frog embryos developed into tadpoles with cranial deformities, and microcephaly was observed in the chick embryos. They traced this effect to an increase in endogenous retinoic acid (RA) activity, and showed that cotreatment with an RA antagonist prevented the deformities.

This increase in RA activity can be explained via inhibition of a CYP enzyme. A novel member of the CYP family has been discovered which is induced by retinoic acid and involved in its catabolism [114,115]. It is present in mammalian embryos and in the brain. Thus, if this enzyme is suppressed by glyphosate, it would explain the observed effect that glyphosate enhances levels of retinoic acid in embryonic development.

A study conducted in 1998 demonstrated that glyphosate inhibits cytochrome P450 enzymes in plants [116]. CYP71s are a class of CYP enzymes which play a role in detoxification of benzene compounds. An inhibitory effect on CYP71B1l extracted from the plant, Thlaspi arvensae, was demonstrated through an experiment involving a reconstituted system containing E. coli bacterial membranes expressing a fusion protein of CYP71B fused with a cytochrome P450 reductase. The fusion protein was assayed for activity level in hydrolyzing a benzo(a)pyrene, in the presence of various concentrations of glyphosate. At 15 microM concentration of glyphosate, enzyme activity was reduced by a factor of four, and by 35 microM concentration enzyme activity was completely eliminated. The mechanism of inhibition involved binding of the nitrogen group in glyphosate to the haem pocket in the enzyme.

A more compelling study demonstrating an effect in mammals as well as in plants involved giving rats glyphosate intragastrically for two weeks [117]. A decrease in the hepatic level of cytochrome P450 activity was observed. As we will see later, CYP enzymes play many important roles in the liver. It is plausible that glyphosate could serve as a source for carcinogenic nitrosamine exposure in humans, leading to hepatic carcinoma. N-nitrosylation of glyphosate occurs in soils treated with sodium nitrite [118], and plant uptake of the nitrosylated product has been demonstrated [119]. Preneoplastic and neoplastic lesions in the liver of female Wistar rats exposed to carcinogenic nitrosamines showed reduced levels of several CYP enzymes involved with detoxification of xenobiotics, including NADPH-cytochrome P450 reductase and various glutathione transferases [120]. Hence this becomes a plausible mechanism by which glyphosate might reduce the bioavailability of CYP enzymes in the liver.

Glyphosate is an organophosphate. Inhibition of CYP enzyme activity in human hepatic cells is a well-established property of organophosphates commonly used as pesticides [121]. In [122], it was demonstrated that organophosphates upregulate the nuclear receptor, constitutive androstane receptor (CAR), a key regulator of CYP activity. This resulted in increased synthesis of CYP2 mRNA, which they proposed may be a compensation for inhibition of CYP enzyme activity by the toxin. CYP2 plays an important role in detoxifying xenobiotics [123].

Beginning in around 2006, an alarming die-off of honeybees became apparent in the United States, and researchers are still struggling to understand what is causing this die-off [124]. Since the application of glyphosate also reached record levels that year, and has continued to increase since then, with no abatement in the bee colony collapse disorder, glyphosate could be playing a role in the bees'

plight. While correlation does not necessary imply causation, there are strong reasons why glyphosate might interfere with bees' resistance to other environmental toxins. At first glance, pesticides might be more highly suspect, since bees are, after all, an insect. However, honeybees have an innate resistance to most pesticides, which unfortunately depends upon several CYP enzymes. For example, metabolic detoxification mediated by CYPs contributes significantly to honey bee tolerance of pyrethroid insecticides [125]. Thus, the fact that glyphosate disrupts CYP enzymes would suggest that exposure to glyphosate would leave bees especially vulnerable to pesticides in their environment, resulting in a synergistic effect. A 2005 study in Alberta (Canada) revealed a reduced wild bee abundance and highly-correlated reduced pollination in GM canola compared with organically grown canola [126], with Roundup-treated non-GM canola coming in at an intermediate level. A study comparing bees exposed to glyphosate and/or Roundup® against a control population demonstrated a significantly higher mortality rate in the glyphosate-exposed bees ($p < 0.001$) [127]. Neonicotinoids such as imidacloprid and clothianidin can kill bees, and have been implicated in colony collapse disorder [128]. However, this toxic effect is likely synergistic in combination with glyphosate, as would occur with bees ingesting herbicide-contaminated pollen. Glyphosate is an organophosphate, and a study of human self-poisoning has demonstrated that organophosphate ingestion synergistically greatly enhances the toxicity of ingested neonicotinoids [129].

6. The Path to Obesity

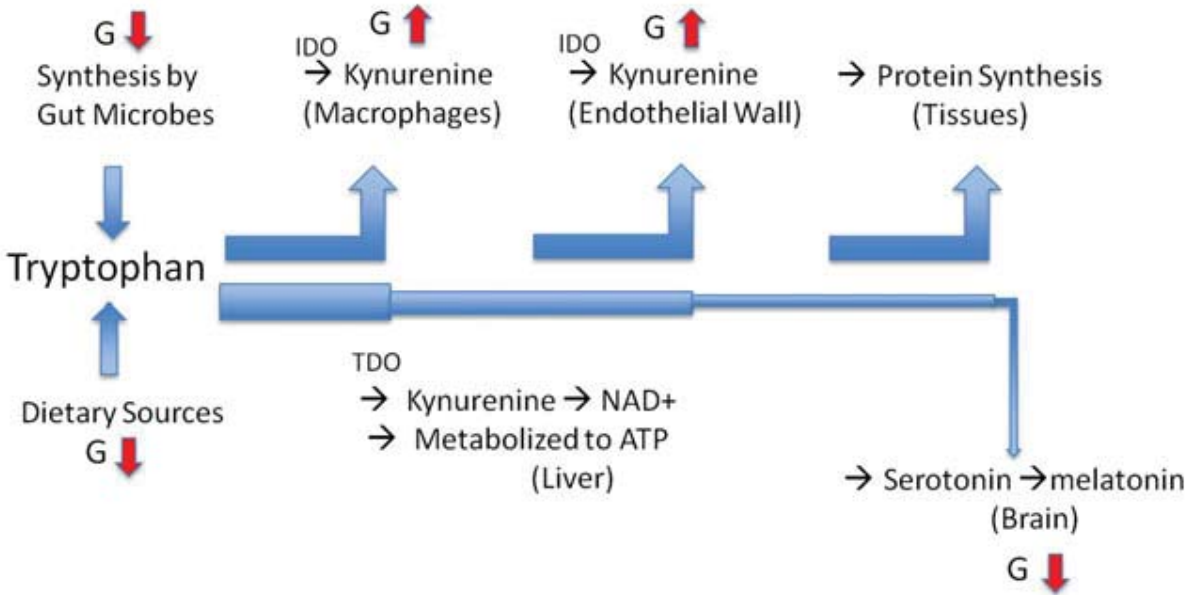
Having established a plausible mechanism whereby glyphosate's effects on gut bacteria would lead to depleted sulfate supplies in the gut with resulting inflammatory bowel disease, we now turn our attention towards the likely consequences of the resulting "leaky gut syndrome." It has been proposed that the exponential increase in the production of synthetic organic and inorganic chemicals may be causal in the current world-wide obesity epidemic, due to alterations in body chemistry that promote weight gain [130]. These chemicals are better known for causing weight loss at high exposure levels, and this apparent paradox can be explained with respect to glyphosate, by invoking its known effect of depleting tryptophan in plants and microbes. Its effect on CYP enzymes in the liver will compound the problem, due to the impaired ability to detoxify synthetic chemicals, which are increasingly present in the environment. In this section we will explain how glyphosate's depletion of tryptophan bioavailability can lead to obesity, and in Section 6 we will provide evidence that extreme depletion of tryptophan in the absence of obesity can cause severe impairment of the intestinal barriers, resulting in weight loss and anorexia, due to an inability to transport critical micronutrients across the damaged gut barrier.

Tryptophan is an essential amino acid, meaning that mammalian cells cannot synthesize it. Serum tryptophan depletion leads to serotonin and melatonin depletion in the brain [131]. Since serotonin (derived from tryptophan) is a potent appetite suppressant [132], it follows that serotonin deficiency would lead to overeating and obesity. As we have seen, tryptophan supplies could be depleted both in plant-based food sources and through impaired tryptophan synthesis by gut bacteria as direct effects of glyphosate. The observed 20-fold increase in the synthesis of tryptophan-derived polyphenolic flavonoids in the context of glyphosate provides strong evidence of impaired tryptophan synthesis [29].

Tryptophan has several important roles in the body. Ordinarily, dietary tryptophan (aside from its role as an essential amino acid in protein synthesis) is taken up by the liver and either fully

metabolized to produce ATP or processed through the enzymatic action of tryptophan dioxygenase (TDO) and indole amine dioxygenase (IDO), via a pathway involving kynurenine and quinolinate as intermediaries to produce NAD+, an essential cofactor in ATP synthesis and DNA repair [133] (see Figure 2). Any tryptophan not taken up by the liver circulates in the blood, and is transported across the blood brain barrier (BBB). It becomes the (sole) precursor to the synthesis of the neurotransmitter serotonin and the hormone melatonin [131]. A low ratio of tryptophan to competing proteins in the blood stream leads to reduced transport of tryptophan across the BBB and subsequent impaired serotonin and melatonin synthesis in the brain. Thus, low serum tryptophan levels translates into a tendency towards weight gain due to suppressed serotonin signaling [132].

Figure 2. Illustration of tryptophan pathways in the body and the adverse effect of glyphosate on tryptophan bioavailability. IDO: indole amine dioxygenase; TDO: Tryptophan dioxygenase; G: glyphosate.



However, under inflammatory conditions, and in response to pathogenic stimuli such as the lipopolysaccharide (LPS) in bacterial cell walls, tryptophan is converted into kynurenine by lymphoid tissues at the site of inflammation [134] and stockpiled by *in situ* macrophages and neutrophils [135–137] as kynurenine. Therefore, it is expected that inflammation in the gut would lead directly to serum tryptophan depletion, thus further reducing the bioavailability of tryptophan to the liver. There are several reasons why macrophages need to sequester kynurenine, the most important of which is likely to be the assurance of a localized resource to regenerate NAD+ following its depletion through the synthesis of poly-ADP ribose by poly(ADP-ribose)polymerase (PARP) [138–140]. Poly-ADP ribose plays an important role in the DNA repair mechanisms that are required following DNA damage, induced by the reactive oxygen and nitrogen species (ROS and RNS) released by macrophages to fight infection – superoxide, nitric oxide, and their reaction product, peroxynitrite. Superoxide is induced from oxygen in the artery wall by transfer of an electron from cytosolic NADPH to oxygen, and its synthesis is essential for killing invasive pathogens, but collateral exposure also leads to tissue damage.

Both the inflammatory cytokine interferon-γ (IFN-γ) and superoxide itself induce IDO synthesis, and IDO detoxifies superoxide by using it to break the pyrrole ring in tryptophan [141]. The DNA in the cell nucleus is highly vulnerable to superoxide exposure, which can lead to strand breaks. The synthesis of kynurenine from tryptophan by IDO results in replenishing the supply of NAD+ and NADP+, which has been depleted due to the activities of PARP as part of the DNA repair process.

Studies have confirmed that serum tryptophan levels are low in association with obesity [142,143]. In [143], plasma tryptophan levels were monitored several times over the course of a twenty-four hour period, and it was confirmed that serum tryptophan levels were chronically depressed, and the levels of other competing large neutral amino acids were elevated, in obese subjects compared to controls. This pathology persisted even after weight reduction through intense dieting.

A recent experiment involving transferring a strain of endotoxin-producing bacteria from the gut of an obese human to the sterile gut of germ-free mice demonstrated the dramatic obesogenic effect that over-production of endotoxin by gut bacteria can have [144]. These mice became obese over a 16-week trial period, when concurrently placed on a high-fat diet, and the obesity was associated with a low-grade chronic inflammatory state. Control germ-free mice on the same diet but without the infective agent did not become obese. It was hypothesized that chylomicrons produced for fat transport became a vehicle for endotoxin delivery to blood serum and subsequently to the liver and body fat stores, since inflammatory cytokines were found predominantly in the liver and epididymal fat pad rather than in the ilium. Since glyphosate induces a shift in gut bacteria towards endotoxin-producers, this effect can conceivably explain the association of a high-fat diet with obesity [145].

The obesity epidemic began in the United States in 1975, simultaneous with the introduction of glyphosate into the food chain, and it has steadily escalated in step with increased usage of glyphosate in agriculture (see Figure 1 in [146]). While it is common knowledge that Americans are continuing to grow more and more obese with each passing year [147,148], there may be less awareness that obesity aligns with glyphosate usage elsewhere in the world [149]. For example, South Africa arguably has the highest obesity rates in all of Africa [150], and it is also the African country that has most heavily embraced glyphosate usage since the 1970's and has freely adopted genetically modified crops with little regulation [151,152]. According to World Health Organization statistics [153], only 2.7% of adults in the United Kingdom were obese in 1972, a number that rose to 25.8% in 1999. Today, two thirds of U.K. citizens are either overweight or obese.

7. The Path to Inflammatory Bowel Disease and Anorexia Nervosa

We have seen how obesity can develop following the depletion of tryptophan through its diversion into polyphenolic flavonoids as well as aggressive uptake into macrophages, to provide assurance of DNA repair mechanisms in the face of excess ROS and RNS. Subsequent impaired serotonin synthesis stimulates overeating behaviors. Here, we argue that severe tryptophan deficiency without sufficient fat stores to harbor toxins and supply sterol sulfates can result in an inability to control microbial invasion as a consequence of impaired release of antimicrobial peptides. This can lead, paradoxically, to anorexia nervosa, resulting in a highly inflamed digestive system, pathogenic penetration through leaky intestinal epithelium, uncontrollable diarrhea, and subsequent anorexia.

Obesity offers protection against gastrointestinal inflammation, in part because the endotoxin can be stored in adipose tissue, sparing the gut barrier from inflammatory damage. However, a more important factor may be the ability of adipose tissue to directly supply sulfated steroids. The sulfotransferase that sulfates serotonin, thus inactivating it, is found in many tissues, including brain, heart, liver, lung, kidney and spleen [154]. Insufficient sulfate supply would likely compromise this function, leading to poor serotonin regulation. There is an interesting connection between levels of serotonin and sterol sulfates in the blood serum. DHEA sulfate is the most prominent sterol sulfate in the serum besides cholesterol sulfate [155]. Patients with autism have anomalously low DHEA sulfate levels along with anomalously low serotonin [156]. Serum DHEA sulfate levels are inversely associated with visceral fat [157], and DHEA sulfate supplements can induce weight loss in morbidly obese postmenopausal women [158]. We hypothesize that DHEA sulfate levels are a hormonal signal of sulfate bioavailability, and low bioavailability leads to low serotonin which induces overeating, in order to produce visceral fat. Visceral fat is a source of estrone sulfate [159], which, we hypothesize, may compensate for some deficiencies in DHEA sulfate and alleviate the burden on the adrenal glands to produce sterol sulfates. This would also reduce the demand on phenols to transport sulfate and therefore alleviate the inflammatory gut disorder, restoring homeostasis.

An important study elucidating the processes leading to inflammatory bowel disorder was conducted on male Ace2 knockout mice (Ace2−/y) [13]. Ace2 induces expression of the tryptophan transporter in the gut epithelium. Thus, these mice suffered from severe tryptophan deficiency. They responded to dextran sodium sulfate exposure with a much more severe colitis attack than their control littermates, leading to enhanced infiltration of inflammatory cells, increased intestinal bleeding, severe diarrhea, and weight loss. A series of further experiments revealed that a similar response could be provoked in the control mice by providing them with a diet that was specifically deficient in tryptophan. It was confirmed that the acute response was associated with impaired synthesis of antimicrobial peptides by macrophages, mediated by impaired mTOR (mammalian target of rapamycin) signaling. It is conceivable that the severe deficiency in tryptophan led to restricted protein synthesis in macrophages, preventing the synthesis of the antimicrobial peptide. Furthermore, the distribution of gut bacteria was profoundly affected by the Ace2−/y phenotype and by tryptophan deprivation.

Thus, severe tryptophan deficiency, as might be induced by glyphosate's interference with tryptophan synthesis in plants and microbes, can lead to an extreme inflammatory bowel disease that would severely impair the ability to absorb nutrients through the gut, due to inflammation, bleeding and diarrhea. This could easily explain the alarming increases that have been seen recently in inflammatory bowel diseases [16,17,160].

8. Cytochrome P450 Enzymes

The cytochrome P450 (CYP) enzymes are a diverse, ancient class of enzymes that date back to three billion years ago, and play an important role in plant, animal, and microbial biology [161]. These enzymes participate in oxidation, peroxidation and reduction of compounds ranging from pharmaceutical drugs to environmental chemicals to endogenous bioactive molecules [123]. There are at least 18 distinct CYP families in humans, which are classified as a series of numerical "CYP" classes. In humans, CYP1, CYP2, CYP3, and CYP4 P450 enzymes in the liver are essential for detoxification of

many xenobiotics [162]. Members of the CYP5 and CYP7 classes are essential for the formation of water-soluble bile acids from cholesterol in the liver. Bile acids act as powerful detergents to aid in the digestion of fats, and also provide a pathway for disposal of oxysterols. A loss-of-function mutation in CYP7B1 leads to liver failure in children, associated with high serum levels of oxysterols [163].

Both cholesterol and vitamin D3 synthesis and degradation depend upon various CYP enzymes. At least seven CYP enzymes have a role in converting acetate into sterols. Lanosterol 14α-desmethylase (CYP51A1) is pivotal in cholesterol synthesis. Two CYP enzymes in the liver catalyze 25-hydroxylation of vitamin D3 to its active form, and two other CYP enzymes catalyze the breakdown of vitamin D3 in the liver [164,165].

There is a growing epidemic of vitamin D deficiency in the United States. In a study on serum 25-hydroxyvitamin D levels obtained from the National Health and Nutrition Examination Survey (NHANES) data, it was found that vitamin D3 levels fell sharply in the interval from 2001 to 2004 compared to the interval from 1988 through 1994 [166]. While this problem is in part due to overaggressive sun avoidance practices, glyphosate's interference with CYP proteins may play a role in disrupting vitamin D3 activation in the liver.

Several CYP enzymes participate in steroid synthesis. Cytochrome P450 oxidoreductase deficiency (POR) is a newly described disorder of steroidogenesis [167]. Five crucial lipid hormones, aldosterone, androstenedione, cortisol, corticosterone and dehydroepiandrosterone (DHEA), are produced in the adrenal glands, testes and ovaries, and in the adrenal cortex. All steroid hormones are produced from cholesterol by these CYP enzymes, contained within the inner mitochondrial membrane. The lipophilic nature of these steroids allows them to diffuse across the lipid bilayers. CYP19A1 (aromatase), whose inhibition has been confirmed in association with glyphosate [109,110] converts androgenic precursors into estrogen. Suppressed aromatase synthesis has been found in the brain in association with autism [168], leading to the "super-male" profile associated with this condition [169].

CYP26A1 catabolizes retinoic acid; hence, its suppression would lead to excess retinoic acid bioavailability. CYP26A1 is induced by retinoic acid during neural differentiation, and its action leads to the degradation of retinoic acid, a necessary step towards maturation of the developing neurons [114]. The aryl hydrocarbon receptor (Ahr) gene induces CYP1B expression, leading to degradation of retinoic acid. Ahr-knockout mice accumulate excess retinoic acid in the liver [170]. Thus, if liver CYP1B expression were disrupted by glyphosate, it would lead to excess retinoic acid. Retinoic acid suppresses the synthesis of cholesterol sulfate, a crucial step in bile acid synthesis [171]; thus, excess retinoic acid in the liver should lead to impaired synthesis of bile acids and impaired fat metabolism.

Mutations in CYP7A1 are associated with high serum LDL and high hepatic cholesterol content, along with deficient bile acid excretion [172]. Human CYP7B1 mutations lead to both defects in bile acid synthesis and spastic paraplegia, involving impaired myelin sheath in the spinal cord and uncontrolled movement disorders. The drug, clopidogrel (Plavix), administered to suppress life-threatening stent thrombosis following cardiovascular surgery, depends upon a liver CYP enzyme, CYP2C19, to transform it into an activated metabolite. Patients with a loss-of-function mutation in this CYP enzyme have significant risk of an adverse event following surgery [173,174].

Glyphosate from food sources or as a contaminant in water would be likely to reach the liver in high concentrations through direct transport from the digestive system via the hepatic portal vein. It could be anticipated that glyphosate would disrupt many of the diverse CYP enzymes that are

bioactive in the liver, involved in cholesterol synthesis and metabolism, vitamin D3 synthesis and metabolism, the detoxification of xenobiotics, and regulation of retinoic acid.

Glyphosate would also be expected to travel throughout the blood stream, disrupting any CYP enzymes it comes in contact with. Of particular concern are the two that regulate blood clotting (thromboxane A2 synthase: CYP5A1) and hemorrhaging (prostacyclin synthase: CYP8A1). CYP5A1 stimulates platelet aggregation, whereas CYP8A1 inhibits platelet aggregation. The elderly often face instabilities in hemorrhaging and clotting leading to Disseminated Intravascular Coagulation (DIC) and life-threatening destabilization of the blood [175], which could be due to impaired function of these two enzymes.

9. Glyphosate's Potential Role in eNOS Dysfunction

Thus far, we have developed a plausible argument for how glyphosate could disrupt gut microbiota, leading to inflammation, depletion of tryptophan, and subsequent obesity, or, in the extreme case, anorexia nervosa. We have also discussed the many roles of CYP enzymes, and proposed that glyphosate's interference with CYP expression could lead to many pathologies that are commonly occurring today, such as vitamin D3 deficiency and abnormal blood clotting.

Endothelial nitric oxide synthase (eNOS) is an orphan member of the CYP family. It is present in endothelial cells that synthesize nitric oxide (NO), where it induces vessel relaxation and therefore enhanced blood flow [176]. Both eNOS and CYP enzymes are heme-thiolate proteins with the same redox partner, a diflavoprotein reductase. However, eNOS, unlike the other CYP enzymes, requires tetrahydrobiopterin (BH4) as a cofactor for the synthesis of NO, and no other member of the CYP family is capable of synthesizing NO.

It has recently been proposed that eNOS is a dual-purpose enzyme, producing NO when it is bound to calmodulin in the cytoplasm, and producing sulfate when it is bound to caveolin at the plasma membrane [177]. While no other CYP enzyme produces NO, this class is known to oxidize sulfur [178], an important aspect of their ability to detoxify sulfur-containing drugs. Red blood cells (RBCs) contain membrane-bound eNOS, and this has presented a puzzle to researchers, because the synthesis of NO by RBCs would be counterproductive, due to its high reactivity with hemoglobin to form a nitrosylated compound that is impaired in oxygen transport. Indeed, RBCs have mechanisms to maintain a very low concentration of the substrate L-arginine. However, it is highly plausible that RBCs use their eNOS to produce sulfate, which can then be combined with cholesterol to form cholesterol sulfate, known to be present in large amounts in RBC plasma membranes, where it has a stabilizing effect.

A significant adverse effect of glyphosate is its hypothesized disruption of sulfate synthesis by eNOS in the endothelium. This effect contributes to the inflammation already present due to the escape of pathogenic bacteria through the impaired gut barrier. In fact, the two effects are synergistic, because the sulfate depletion incurred by eNOS dysfunction further compromises the gut barrier, where sulfate deficiencies due to transport problems are already present. Due to its homology with the CYP enzymes, eNOS is predicted to be susceptible to disruption by glyphosate, but only in its sulfate-synthesis function. The result will be endothelial damage due to superoxide exposure, along with sulfate deficiency. We hypothesize that such disruption is a significant heretofore overlooked component of glyphosate's toxicity in mammals.

If, as proposed in [177], RBCs use eNOS to produce sulfate, then the sulfate can be combined with cholesterol to produce cholesterol sulfate, which, unlike cholesterol itself, is amphiphilic. RBCs are well positioned to deliver both cholesterol and sulfate to the tissues, supplying them with these essential nutrients. In [177], it was further proposed that endothelial cells produce sulfate catalyzed by eNOS, using superoxide as the oxidizing agent, a reaction that is catalyzed by sunlight exposure, and that the sulfate serves to replenish sulfate supplies to the glycocalyx, which is constructed from highly sulfated proteoglycans. Accumulation of sulfate deficiencies in the endothelial glycocalyx contributes significantly to vascular dysfunction [179]. Colitis is less prevalent in areas with a sunny climate [180], suggesting that sunlight improves intestinal health by increasing sulfate supply.

Ingested glyphosate readily enters the vasculature, and hence membrane bound eNOS in RBCs and the endothelial wall is vulnerable to the disabling effects of glyphosate on the P450 active site. This, over time, would result in cholesterol and sulfate deficiencies, manifested as multiple disease states. It would also explain the pathology where eNOS synthesizes superoxide in an "uncoupled" mode [181], a pathology that has been proposed as a major source of inflammatory ROS and subsequent endothelial dysfunction. We hypothesize that the superoxide is prevented from oxidizing sulfur by the glyphosate, and thus becomes a destructive agent in the artery wall.

9.1. Lysosomal Dysfunction

In [177], it was proposed that lysosomal dysfunction could be predicted to follow long-term impairment of eNOS' sulfate synthesis. Lysosomes, the "digestive system" of the cell, require substantial membrane cholesterol both to prevent hydrogen ion leaks and to protect membrane lipids from oxidative damage. Lysosomes also depend upon internalized sulfate, derived from heparan sulfate proteoglycans (HSPGs), to catalyze hydrolytic enzymes. Severe neurological dysfunction associated with lysosomal storage diseases involving impaired heparan sulfate homeostasis attest to the importance of sulfate in lysosomal function [182].

It has become increasingly apparent that lysosomal dysfunction is a major factor in Alzheimer's disease and Parkinson's disease [183], as well as in cardiovascular disease [184] and heart failure [185]. Mitochondria are ordinarily constantly broken down and renewed by lysosomal processes, and, when these become impaired, large aged mitochondria become a source of reactive oxygen species that contribute significantly to neuronal damage. Cardiomyocytes, like neurons, are long-lived postmitotic cells that are especially susceptible to lysosomal disrepair [186].

9.2. Tetrahydrobiopterin

The research literature has identified the cofactor tetrahydrobiopterin (BH4) as a significant player in eNOS function [187,188]. BH4 shifts the heme iron in eNOS to a high spin state, as well as increasing arginine binding, thus catalyzing the synthesis of NO by eNOS [187]. The synthesis of BH4 from its substrate GTP is induced by IFN-γ, which, in turn, is induced by bacterial lipopolysaccharides (LPS) [189]. Thus, a bacterial infection will induce NO synthesis by eNOS. However, an excess of exogenous NO (as might be expected to occur through iNOS synthesis of NO during a bacterial infection) causes a decrease in NO synthesis by eNOS with a simultaneous increase in superoxide synthesis, an effect that can lead to severe hypertension in infants with congenital heart disease treated

with inhaled NO [187]. Superoxide's reaction with NO to produce the highly toxic peroxynitrite (ONOO−), a potent bacteriocidal agent, is likely a critical factor. The subsequent oxidation of BH_4 disrupts its ability to act as a cofactor [188], and causes "eNOS uncoupling," leading to superoxide synthesis in a highly disruptive feedback loop.

We hypothesize that glyphosate's nitrosylation of the active P450 site has derailed eNOS' ability to synthesize sulfate in a contained environment at the caveolar sites in the membrane, thus requiring an alternative method to synthesize sulfate that exposes the cell to ROS. This method, as previously described in [177,190], involves the oxidation of homocysteine thiolactone, catalyzed by ascorbic acid (vitamin C) and retinoic acid (vitamin A). Since glyphosate enhances the bioavailability of retinoic acid through its suppression of the CYP enzyme that metabolizes it [115], this will help to promote the alternative reaction leading to sulfate synthesis in the artery wall from homocysteine thiolactone, but also requiring the inflammatory agent, superoxide, which over time destroys the artery wall, leading to endothelial dysfunction and cardiovascular disease.

Elevated serum homocysteine is a strong risk factor in cardiovascular disease [191], in heart failure [192], in dementia [193], and in kidney failure [194,195]. We propose that sulfur-containing amino acids are deflected towards homocysteine synthesis in order to supply substrate for the critically-needed sulfate synthesis from superoxide in the artery wall. This also explains both the inflammation in the artery wall associated with atherosclerosis [196] and the deficiency in methionine associated with glyphosate, due to its depletion through its role as a substrate for homocysteine synthesis.

10. Involvement of the Brain

Impairment in the homeostasis of serotonin, an important neurotransmitter that regulates mood, appetite and sleep, has been linked to depression [197], autism [198], and Alzheimer's disease [199,200], as well as obesity [132]. We have already seen how glyphosate's induction of tryptophan-derived flavonoids and tryptophan's incorporation into macrophages as kynurenine via IPO can explain reduced brain serotonin levels. Vitamin D3 deficiency can also contribute to mood disorders, and is hypothesized to be a key factor in the syndrome, Seasonal Affective Disorder (SAD), manifested as depressed mood specifically during the winter months [201]. Excess ammonia and zinc deficiency are also implicated in neuronal disorders, particularly Alzheimer's disease, attention deficit hyperactivity disorder (ADHD), and autism. DNA methylation impairment is a factor in neuronal diseases, and glyphosate's depletion of methionine could contribute to this defect. Below, we elaborate on the effects of serotonin depletion, excess ammonia, zinc depletion, and methylation impairments on disorders of the brain. We conclude this section with specific mention of a possible role for glyphosate in two other diseases of the brain: multiple sclerosis and Parkinson's disease.

10.1. Serotonin, Mood Disorders, and Autism

Defects in serotonin transport are associated with a wide range of mood disorders. Major depression is accompanied by immune system activation, and the term "inflammatory and neurodegenerative (I&ND) hypothesis" has been used to describe this complex [202]. A demonstrated increased production of cytokines and immunoglobulins against bacterial-derived lipopolysaccharides points to increased gut permeability as a feature in depression [203]. Patients with depression and sleep disorders exhibit significantly lower

serum levels of tryptophan along with serum markers of inflammation such as IL-6 and IL-8 [204]. Selective serotonin reuptake inhibitors (SSRI's) are a popular class of drugs to treat depression: they work by impairing serotonin reuptake in the synapse, effectively increasing its bioavailability for neuronal signaling. This strongly suggests that insufficient serotonin in the synapse could be a factor in depression. In fact, dietary tryptophan depletion leads to relapse in recovering depressed patients [197].

Defects in the serotonin transporter gene, 5-HTT, have been associated with antisocial personality disorder and violent behavior [205]. There has been a marked increase in the rate of irrational school-associated violent deaths in the United States since 1990 [206], and glyphosate may play a role in this pattern through depletion of serotonin bioavailability. Disturbances in serotonin function in the brain are known factors in impulsive aggression, violence, and criminal behavior [207]. Farmers in India experienced anomalously high suicide rates following adoption of Western agricultural methods based on extensive use of Roundup® [208]. While an explanation based on economic stress has been proposed, suicide victims in general have low serotonin levels in the brain [209], so it is conceivable that serotonin suppression via depletion of tryptophan by glyphosate played a role in the suicides among farmers in India.

Genetic mutations in serotonin transporter genes have been found in association with both obsessive compulsive disorder and autism [210]. A study comparing 40 children with idiopathic infantile autism with normal controls showed a significantly lower serum ratio of tryptophan to large neutral amino acids [211]. 35% of the children with autism had a ratio that was at least two standard deviations below the mean value from the control group. It has been shown that dietary tryptophan depletion exacerbates anxiety and repetitive ritualistic behaviors in autistic subjects [198], an effect that was surmised to be due to impaired serotonin synthesis. Researchers have studied a mouse model of a defective serotonin transporter gene which results in a decrease in the bioavailability of serotonin for neuronal signaling in the brain, and have shown that the genetically modified mice exhibit autism-like behaviors [212]. This strongly suggests that impaired serotonin supply in the brain is a feature of autism.

Melatonin, produced from serotonin, is secreted by the pineal gland, primarily at night, and is a potent antioxidant and regulator of redox reactions [213,214]. Its neuroprotective role in aging and many neurodegenerative conditions such as Alzheimer's disease and Parkinson's disease is most likely due to its antioxidant effects [215–218]. Thus, it is anticipated that glyphosate would lead to impaired antioxidant protection, due to the suppression of melatonin synthesis, following the depletion of tryptophan as substrate, as previously discussed. Since melatonin is also a regulator of the wake/sleep cycle, impaired melatonin supply will lead to sleep disorders.

10.2. Ammonia, Autism and Alzheimer's Disease.

As stated previously, glyphosate enhances ammonia synthesis in susceptible plants via activation of the enzyme PAL [22], and gut microbes could produce excess ammonia through enhanced PAL synthesis under the influence of glyphosate. A parallel between autism and hepatic encephalitis has been made, emphasizing the role that ammonia plays as a toxin in the brain in both cases [219,220]. Ammonia has also been proposed to play a critical role in the etiology of Alzheimer's disease [221]. Thus, excess ammonia synthesis by gut bacteria under the influence of glyphosate could be a factor in both autism and Alzheimer's disease.

10.3. A Role for Zinc Deficiency.

Zinc deficiency is a major problem worldwide, particularly in the developing world, where limited access to zinc-rich foods such as shellfish and excess dietary exposure to phytates both contribute to the problem [222]. Phytates, found in many nuts and grains, bind to dietary minerals and interfere with their absorption. *Lactobacilli* and other beneficial gut bacteria produce the enzyme phytase, which catalyses the release of phosphate from phytates and improves the intestinal absorption of important minerals such as iron and zinc [223]. Because glyphosate reduces the number of these types of bacteria in the gut, it should enhance the chelating potential of phytates. This is likely a protective measure to avoid excess bioavailability of free phosphate, which is problematic in transport in the presence of glyphosate. Glyphosate's known ability to itself chelate divalent cations is likely a factor as well. Zinc deficiency increases the risk of diarrhea, pneumonia and malaria in infants and young children.

Zinc is the most abundant trace metal in the brain [224]. Most of the amyloid-β degrading enzymes are zinc metalloproteases, and zinc is also critical in the nonamyloidogenic processing of the amyloid precursor protein. Hence, zinc deficiency in the brain would be expected to lead to the build-up of amyloid-β, a key factor in the development of Alzheimer's disease. Zinc deficiency has also been implicated in autism [225] and ADHD [226,227]. Zinc is released into the synapse along with the neurotransmitter glutamate, and it is required for memory function and the maintenance of synaptic health as we age [228]. In [225], anomalously low zinc levels in hair analyses were found in children on the autism spectrum. In [226], zinc sulfate supplements improved ADHD symptoms, an effect that could be attributed to the supply of sulfate as well as zinc.

In [229], it was proposed that zinc deficiency along with excess exposure to copper may be a key factor in Alzheimer's disease. A study conducted in South Africa revealed that zinc supplementation was not effective in raising plasma levels of zinc in zinc-deficient Alzheimer's patients unless both vitamin A and vitamin D were simultaneously supplemented [230]. Hence, vitamin D3 deficiency (which could be caused by glyphosate's impairment of liver CYP enzymes) may interfere with zinc absorption, further depleting the supplies to the tissues.

10.4. Methylation Impairment

Methylation impairment has been observed in association with autism [231] and Alzheimer's disease [232], and this is caused by an inadequate supply of the substrate, methionine. While human cells are unable to synthesize methionine, it can be synthesized by many enteric bacteria, for example from cysteine via the transsulfuration pathway or through de novo synthesis from inorganic sulfur [233]. Glyphosate has been shown to significantly impair methionine synthesis in plants [21], and it may therefore be anticipated that it would have a similar effect in gut bacteria, which could then impair methionine bioavailability in humans. A further factor is the depletion of methionine through its deflection towards the transsulfuration pathway, as a precursor for homocysteine, which will be consumed to supply sulfate to the endothelial wall when eNOS' sulfate synthesis is impaired. Since methionine is the source of methyl groups in methylation pathways, this effect of glyphosate could contribute directly to methylation impairment.

10.5. Molecular Mimicry and Multiple Sclerosis

An increased incidence of inflammatory bowel disease has been found in association with multiple sclerosis (MS) [234]. This could be explained by the hypothesis that gut bacteria leaking into the vasculature cause an immune reaction, and that molecular mimicry leads to an autoimmune disorder resulting in destruction of the myelin sheath. A systematic search comparing reported sequences from all known human bacterial and viral agents against three known encephalitogenic peptides identified matching mimics predominantly in gut bacteria [235]. This could explain why no infective agents have been found in association with MS, but would also suggest that the recent increase in the incidence of MS [236] may be traced to inflammatory bowel disease, and, hence, to glyphosate.

10.6. Dopamine and Parkinson's Disease

Since dopamine is synthesized from tyrosine and its precursor phenylalanine, tyrosine and phenylalanine depletion by glyphosate in both plants and microbes would be expected to reduce their bioavailability in the diet. It has been demonstrated that dietary reductions of phenylalanine and tyrosine induce reduced dopamine concentrations in the brain [237]. Impaired dopaminergic signaling in the substantia nigra is a key feature of Parkinson's disease, and Parkinson's risk has been associated with exposure to various pesticides, including the herbicide paraquat [238], although, to our knowledge, glyphosate has not yet been studied in this respect. However, exposure of C. elegans to glyphosate led to pathology in the nervous system in the region analogous to the nigrostriatal dopamine system associated with Parkinson's disease [239].

Sulfate deficiency in the brain has been associated with Parkinson's disease, as well as Alzheimer's disease and Amyotrophic Lateral Sclerosis (ALS) [240]. We have argued above that glyphosate disrupts sulfate transport from the gut to the liver, and may interfere with sulfate synthesis by eNOS in the arterial wall and in RBCs and platelets, leading over time to severe sulfate deficiency throughout all the tissues. This would further impact these devastating diseases of the elderly, all of which are currently on the rise.

11. Other Adverse Health Effects

In this section, we will briefly mention several other pathologies in which we suspect that glyphosate may play a role in the observed increases in incidences in recent times. These include liver disease, cancer, cachexia, and developmental and fertility problems.

11.1. Liver Disease

Cytokines like TNF-α have been identified as a key factor in fatty liver disease, which has emerged as a growing public health problem worldwide [241]. In the extreme case, liver pathology develops into nonalcoholic steatohepatitis (NASH), which can lead to cirrhosis and liver failure. Cytokines induce inflammation which damages the liver. TNF-α inhibits insulin signaling [242,243], and cytokines can induce hepatic lipid overloading as well as liver fibrosis. Glyphosate's role in inducing cytokines has already been developed in this paper. Obesity is associated with an increased expression of membrane-associated TNF-α in adipose tissue [244].

11.2. Development and Fertility

Cholesterol sulfate plays an essential role in fertilization [245] and zinc is essential to the male reproductive system [246], with a high concentration found in semen. Thus, the likely reduction in the bioavailability of these two nutrients due to effects of glyphosate could be contributory to infertility problems. Furthermore, glyphosate's suppression of CYP protein activity would be expected to disrupt steroidogenesis. Inflammation leads to excess ROS and RNS exposure, which can damage DNA during cell replication, thus disrupting embryonic development. Glyphosate is capable of crossing the placental barrier [247]. Preeclampsia, a life-threatening condition for both the mother and the fetus that develops during the third trimester, is on the rise in America, and it has been proposed that this may be due to impaired sulfate supply [248], directly attributable to glyphosate exposure. For all of these reasons, glyphosate exposure would lead to infertility problems.

According to the World Bank, the fertility rate in Argentina peaked at 3.39 in 1978, and has been declining steadily since then. The rate of decline accelerated during the last five years of the twentieth century. Social pressures certainly explain some of the drop in birth rate, but it is possible that environmental factors, such as glyphosate, also play a role. 1994 was the year that the FDA authorized the sale of Roundup Ready® (RR) soybeans in the North American market [249], and Argentina followed suit two years later. "After they were authorized in 1996, RR soybeans spread through Argentina at an absolutely unprecedented speed in the history of agriculture: an average of more than two million acres a year." [249]. Argentina now exports 90% of its soybeans, which have become a monoculture crop and a cash cow.

The fertility rate in Brazil has also dropped dramatically over the past several decades from six children per woman on average to fewer than two, now lower than that of the United States. Brazil is the second largest producer and exporter of soybeans in the world behind Argentina, and it has embraced genetically modified soybeans engineered to be glyphosate-tolerant as a means to increase production since the mid 1990's. A rapidly evolving glyphosate-resistant weed population in Brazil due to genetically engineered glyphosate-tolerant crops is leading to increased use of glyphosate in recent years [250], the same time period in which a rapid drop in birth rates was observed. A steady increase in the rate of preterm births in Brazil over the past two decades has been noted, although the cause remains elusive. For instance, the rate increased from 6% in 1982 to 15% in 2004 in the town of Pelotas [251]. It is conceivable that increased exposure to glyphosate is contributing to this problem. This idea is in line with a study of an Ontario farm population, which revealed that glyphosate exposure any time during pregnancy was associated with a statistically significant increased risk of a late-pregnancy spontaneous abortion [252].

The birth rates in Western Europe have been declining for decades, with Germany's rate now being 1.36 children per woman. Birth rates have also been declining in the U.S since 2007, and are now at 1.9 children per woman, according to the 2011 government statistics [253].

Testicular Leydig cells produce testosterone, and thus play a crucial role in male reproductive function. The protein StAR (steroidogenic acute regulatory protein) mediates the rate-limiting step in steroidogenesis. In a recent *in vitro* study of a mouse tumor Leydig cell line, Roundup was shown to disrupt StAR expression, thus interfering with testosterone synthesis [254]. It was shown that

Roundup® interferes with testosterone synthesis even at very low environmental doses, and higher doses were associated with necrosis and apoptosis in rat testicular cells.

In [255], the *in vitro* effects of several different pesticides and herbicides on the synthesis of progesterone in testicular Leydig cells were investigated. Comparing eight different pesticides (Ammo®, Banvel®, Cotoran®, Cyclone®, Dual®, Fusilade® and Roundup®), it was found that, among these eight, Roundup® uniquely disrupted the cells' ability to produce progesterone, reducing synthesis levels by up to 94% in a dose-dependent manner, without reducing total protein synthesis.

For steroidogenesis, in addition to StAR, the side chain cleavage enzyme (P450scc) is required as well. The authors in [255] found that Roundup® inhibited both P450scc activity and StAR activity. Through formal measurements, it was determined that Roundup® reduced StAR protein levels by 90%, and inhibited P450scc activity by 71%. Glyphosate acting alone did not decrease steroidogenesis, suggesting that one or more of the adjuvants in Roundup® work in concert with glyphosate to suppress synthesis levels, *e.g.*, by enabling glyphosate entry into the cell through a surfactant effect or perhaps acting on their own to inhibit synthesis. StAR plays an important role in steroid production not only in the reproductive organs but also in the adrenal glands. Thus, Roundup® exposure would be expected to adversely affect fertility and impair the synthesis of glucocorticoids and mineralocorticoids in the adrenal glands.

Sea urchins are a popular model for studying mitosis in development. During mitosis, DNA damage or replication errors (for example due to excess exposure to ROS and RNS) leads to cell cycle arrest at certain "checkpoints" in G1, S, or G2 phase [256]. Cyclin-dependent protein kinases (CDKs) are important regulators of these checkpoints, signaling the "go-ahead" to transition to the next phase. Glyphosate in combination with the adjuvants in Roundup® experimentally induced a cell cycle delay in the transition from G2 to M phase in sea urchin embryos [257,258]. CDK1, acting on cyclin B, universally regulates the M-phase of the cell cycle, and Roundup® was shown to delay activation of CDK1/cyclin B via tyrosine 15 dephosphorylation *in vivo*, the likely means by which it interferes with cell cycle progression.

11.3. Cancer

While glyphosate is not generally believed to be a carcinogen, a study on a population of professional pesticide applicators who were occupationally exposed to glyphosate revealed a substantial increased risk to multiple myeloma [259]. Myeloma has been associated with agents that cause DNA damage [260], and DNA damage is a known consequence of chronic exposure to inflammatory agents, which, we have argued, are induced by glyphosate acting on the gut bacteria and suppressing CYP activity. Depleted supply of tryptophan as a substrate for poly-ADP ribose also contributes to DNA damage.

Multiple myeloma accounts for around 15% of all lymphatohematopoietic cancers and around 2% of all cancer deaths each year in the United States [261]. Symptoms include bone destruction, hypercalcemia, anemia, kidney damage and increased susceptibility to infection. Obesity is a known risk factor [261], so one way in which glyphosate could increase risk indirectly is through its potential role as an obesogen.

Virtually all multiple myelomas involve dysregulation of a cyclin D gene [262]. Overexpression of cyclin D protein releases a cell from its normal cell-cycle control and could cause a transformation to a malignant phenotype. The fact that glyphosate suppresses cyclin-dependent kinase could be a factor in inducing pathological overexpression of the substrate, cyclin D.

Another type of cancer that may be implicated with glyphosate exposure is breast cancer. The strongest evidence for such a link comes from the studies on rats exposed to glyphosate in their food supply throughout their lifespan, described previously, where some of the female rats succumbed to massive mammary tumors [9]. The incidence of breast cancer has skyrocketed recently in the United States, to the point where now one in three women is expected to develop breast cancer in their lifetime.

Breast cancer risk is associated with certain polymorphisms of the CYP gene CYP1A2 and the sulfotransferase, SULT1A1 [263], and this in turn is associated with altered estrogen and testosterone expression, along with increased premenopausal breast density, a risk factor for breast cancer [264]. In [263], it was suggested that impaired sulfation capacity could lead to slower metabolism of sex hormones and subsequent increased breast density, as well as increased risk to breast cancer. This suggests that disruption of CYP1A2 and/or of sulfate bioavailability by glyphosate could lead to a similar result. A high body mass index (BMI) is associated with low CYP1A2 activity in premenopausal women (p = 0.03) [265], and, as we have seen, the low CYP1A2 activity may be a reflection of glyphosate suppression of CYP enzymes, in association with glyphosate depletion of tryptophan as an obesogenic influence, and glyphosate disruption of sulfate synthesis by eNOS.

Obese postmenopausal women are at increased risk to breast cancer compared with lean postmenopausal women [266]. Studies on Zucker rats exposed to 7,12-dimethylbenz(a)anthracene, a chemical procarcinogen known to produce mammary adenocarcinoma in rats, demonstrated a much stronger susceptibility in obese rats compared to lean rats [267]. By the end of the study, obese rats had a 68% tumor incidence, compared to only 32% in lean rats. Subcutaneous fat expresses aromatase, and this increased expression has been suggested to play a role in inducing the increased risk, through the resulting increased estrogen synthesis [268,269]. It has been shown that inflammation increases aromatase expression in the mammary gland and in adipose tissue. Since we have developed an argument that glyphosate can lead to inflammation, this again suggests a link between glyphosate and breast cancer.

11.4. Cachexia

Cachexia (muscle wasting) is a frequent debilitating complication of cancer, AIDS, and other chronic inflammatory diseases. The loss of muscle mass arises from accelerated protein degradation via the ubiquitin-proteasome pathway, which requires ubiquitin conjugating of designated proteins prior to their disposal [270]. The ubiquitin-conjugating pathway is stimulated by TNF-α, thus promoting muscle breakdown. In [271], it was shown that TNF-α upregulates expression of the ubiquitin ligase atrogin1/MAFbx in skeletal muscle, via the mitogen-activated kinase (MAPK) pathway. Thus increased TNF-α expression as a consequence of the inflammatory response associated with glyphosate exposure could be a factor in cachexia.

12. Glyphosate in Food Sources

Following its successful commercial introduction in 1974 in the U.S., glyphosate has now become the dominant herbicide worldwide [6]. In large part this is due to its perceived lack of toxicity in humans. Since becoming generic in 2000, the dramatic drop in cost has encouraged global use of the generic version. Today, it is estimated that 90% of the transgenic crops grown worldwide are glyphosate resistant. The rapidly growing problem of glyphosate-resistant weeds is reflected in steady increases in the use of glyphosate on crops.

Table 1. Estimated range for glyphosate usage in agriculture in the U.S. as a function of year. Range is estimated in units of millions of pounds. These data were obtained from the EPA [272].

Glyphosate usage for the USA (Range in millions of pounds)				
Year	2001	2003	2005	2007
Range	85–90	128–133	155–160	180–185

Today, Americans spray more than 100 million pounds of Roundup®, the most popular among Monsanto's chemicals, on their yards and farms every year. According to the most recent statistics from the U.S. Environmental Protection Agency (EPA) [272], the U.S. currently represents 25% of the total world market on herbicide usage. Glyphosate, first registered for use in 1974, has been the most common herbicide used in the United States since 2001, and the amount of glyphosate usage has increased steadily since then, as shown in Table 1. In 2007, the most recent year for which such numbers are available, the U.S. used an estimated 180 to 185 million pounds of glyphosate, more than doubling the amount used just six years before.

The Western diet is a delivery system for toxic chemicals used in industrial agriculture. The diet consists primarily of processed foods based on corn, wheat, soy and sugar, consumed in high quantities. Chemical residues of insecticides, fungicides and herbicides like glyphosate contaminate the entire diet. Over the last decade, there has been widespread adoption in the U.S. of Roundup Ready® (RR) crops, particularly for the major productions of soy, beet sugar, and corn that supply the processed food industry. The recent alarming rise in type-2 diabetes has been attributed to excess intake of high fructose corn syrup, which has increased to unprecedented levels in the last decade [273]. This refined sugar is now usually derived from glyphosate-exposed GM corn. GM cotton is also increasingly being used as a source for cottonseed oil, widely present in processed foods such as potato chips, due to its low cost. A recent comparison between glyphosate-sensitive and glyphosate-resistant soybean crops revealed that the resistant plants took up much higher levels of glyphosate into their leaves [274]. A corollary is that these plants would be expected to yield much higher glyphosate concentrations in derived food sources, compared to their non-GMO counterparts.

Confined animal feeding operations (CAFOs) are used to produce dietary animal protein for a mostly non-agrarian population [275]. Cows, pigs, sheep, goats, chickens and even farm-raised fish and shrimp are fed a diet primarily of genetically engineered grains and forage materials laced with herbicide. As a consequence, animal products like, eggs, butter, cheese and milk are also contaminated with these residues. The highest levels of glyphosate are found in grain and sugar crops. The herbicide

is not only used with RR crops, but also, as previously mentioned, it is used as a preharvest desiccant on sugar cane, wheat and also RR sugar beets, canola, and cottonseed for oils, among others.

It is difficult to get information on actual amounts of glyphosate present in foods, due to the perception that it is nontoxic to humans [1,6]. The USDA Pesticide Data Program (PDP) is a voluntary program which randomly monitors agricultural chemical residues in the food supply. A search of the most recent data for 2010, published in May 2012, found statistics for the most popular agricultural chemicals except for glyphosate and glufosinate, another organophosphate. Residue data for the most popular herbicide on the planet were not available, but, interestingly, information on atrazine and other herbicides were readily available. Communication with USDA revealed that no data were available due to lack of monitoring. However, in 2013, for the first time, the USDA will be releasing a small amount of data for glyphosate residues only in soy. Lack of program funding was cited as the reason for this lack of data.

Recently, residue levels have been on the rise, due to higher rates and frequency of application, which in turn is due to increasing weed resistance. This has led the chemical and biotech industry to demand approvals for higher residue standards. In 1999 both the European Union (EU) and the UK raised the maximal glyphosate levels allowed in soy for industry from 0.1 ppm to 20 ppm. Both the USA and Argentina supply glyphosate-laden grains to European markets, so one could expect to find similar levels in the U.S.

The European Union's current standard for glyphosate in lentils is 0.1 mg/kg but a new industry proposal seeks to raise the standard by more than 100 times to 10 mg/kg or even 15 mg/kg [276]. This is not due to safety considerations, but rather to levels that are anticipated, following usage of the herbicide as a preharvest desiccant. The action will ignore the possible effects to public health. The effects of animal health from ingestion of glyphosate residues have also been ignored. Current standards for residues in feed and forage materials are totally out of line with those of humans. Tolerances for animal grass and corn forage are 300 and 400 ppm respectively. It is apparent that the EPA standard is being ignored on a global scale for industry at the expense of public health and the environment.

13. Discussion

Glyphosate is today the most popular herbicide in use in agricultural practices in the U.S., and, increasingly, throughout the world. Its usage rate has accelerated significantly in the last decade due mainly to two factors: (1) the patent expiration in 2000 led to greatly reduced cost, and (2) the adoption of genetically modified crops that are resistant to its toxic effects allows for higher exposure with little loss in harvest yield. The notion that glyphosate has minimal toxicity in humans, widely popularized by Monsanto, has prevented farmers from using caution in their application of this chemical to their crops.

The recent rise in the rates of autism diagnoses in the United States is a cause for alarm. We have recently proposed that autism can be characterized as a chronic low-grade encephalopathy, where the cascade of events taking place in the brain is a process that enables the renewal of severely depleted sulfate supplies to the brain [277]. We identified a dysbiosis in the gut as a source of ammonia that initiates the encephalytic response, and we proposed glyphosate as one of the many environmental toxins that might be responsible for the dysbiosis and for sulfate depletion. A review of the literature

on glyphosate has confirmed our suspicions that glyphosate might play a role, and, further, have led us to believe that glyphosate may be the most significant environmental toxin contributing to autism. While it is pervasive in our food supply, the fact that it is deemed by most regulators to be nontoxic makes it especially insidious. The key pathological biological effects of glyphosate -- disruption of the gut bacteria, impairment of sulfate transport, and interference with CYP enzyme activity—can easily explain the features that are characteristic of autism.

The term "developmental immunotoxicity" has been coined to describe permanent modifications to the immune function that take place early in life, leading to later development of allergies, asthma, and autoimmune diseases [278–280]. These authors have argued that prenatal and/or early life exposure to environmental toxins can lead to a phenotype that includes a hyperinflammatory response and disruption of cytokine networks, and they propose that an increased exposure to environmental toxins early in life may contribute to the increased incidence of these conditions observed today. It is significant that these problems often occur in association with autism [281].

Contrary to the current widely-held misconception that glyphosate is relatively harmless to humans, the available evidence shows that glyphosate may rather be the most important factor in the development of multiple chronic diseases and conditions that have become prevalent in Westernized societies. In addition to autism, these include gastrointestinal issues such as inflammatory bowel disease, chronic diarrhea, colitis and Crohn's disease, obesity, cardiovascular disease, depression, cancer, cachexia, Alzheimer's disease, Parkinson's disease, multiple sclerosis, and ALS, among others. While glyphosate is obviously not the only environmental toxin to contribute to these diseases and conditions, glyphosate's ability to disrupt the gut bacteria, to impair serum transport of sulfate and phosphate, and to interfere with CYP enzymes, logically progresses to this multitude of diseased states, through well-established biological processes. And glyphosate's disruption of the body's ability to detoxify other environmental toxins leads to synergistic enhancement of toxicity. While genetics surely play a role in susceptibility, genetics may rather influence *which* of these conditions develops in the context of glyphosate exposure, rather than *whether* any of these conditions develops.

We have explained the logical sequence of events leading to serotonin deficiency and subsequent pathologies, following glyphosate's disruption of tryptophan synthesis by gut bacteria [10,29], and its further sequestration into macrophages that infiltrate the intestinal tissues in order to detoxify lipopolysaccharides released from pathogenic bacteria, whose overgrowth is induced by glyphosate [35]. Sulfate depletion arises in the gut, both because of impaired transport of free sulfate in the bloodstream and impaired sulfate synthesis by eNOS [63,64]. Disruption of gut bacteria, exposure to toxic phenolic compounds necessary to enable sulfate transport, and deficient sulfate supply to the mucopolysaccharides in the gut all contribute to the leaky gut syndrome that is a common feature in autism [51]. The evidence shows that glyphosate can interfere with development through its suppression of aromatase synthesis [110] and through its interference with the breakdown of retinoic acid [113] and its interference with CDKs and sulfate supplies. Glyphosate could also be a factor in the current epidemic in vitamin D3 deficiency [166] through its disruption of the CYP enzymes that activate this hormone in the liver [164,165]. The kosmotropic property of the glyphosate molecule combined with its disruption of CYP enzymes in the blood stream can lead to excess thrombosis and hemorrhaging, common problems today among the elderly.

We propose that glyphosate's disruption of the synthesis of sulfate by the CYP orphan enzyme, eNOS, leads to widespread deficiencies in cholesterol and sulfate in the blood stream and all the tissues. We have previously described how disruption of eNOS' synthesis of sulfate would lead to diabetes and cardiovascular disease [177]. Glyphosate's induction of excess synthesis of ammonia in the gut, combined with depletion of zinc through impaired absorption, depletion of serotonin through dysbiosis of its substrate, tryptophan, depletion of dopamine through impaired synthesis of its substrate, tyrosine, depletion of vitamin D3, due to impairments in the CYP enzyme responsible for its activation, and depletion of sulfate through interference with its synthesis, can all lead to a multitude of pathologies in the brain, including autism, Alzheimer's disease, ADHD, Parkinson's disease, multiple sclerosis and ALS.

There is a substantial alignment among countries, worldwide, with low or decreasing birth rates, emerging obesity problems, and an increasing glyphosate burden. Given the arguments presented here, it is plausible that glyphosate is causal in these trends. It may also be possible to demonstrate strong correlations between glyphosate usage and both autism and breast cancer. Formal epidemiological studies should be conducted to look at these issues more closely.

In our opinion, it is imperative that governments around the globe unite in investing significant research funds to support independent studies evaluating the long-term effects of glyphosate. Other researchers should try to reproduce the results obtained in [9] showing tumorigenesis and premature death in rats with life-long exposure to glyphosate. The study on the gut microbiome of chickens [35] needs to be reproduced in other species, and the gene array study on *E. coli* [39] needs to be reproduced for other common gut bacteria. The novel idea that glyphosate disrupts sulfate transport through its kosmotropic effects, as predicted given biophysical laws, needs to be verified in specific studies among a variety of species. This could be done by comparing the levels of free sulfate in the blood under conditions of glyphosate exposure against controls. The study on glyphosate's effects on bees [126] should be reproduced by other researchers, along with further studies examining the impact of prior exposure to glyphosate on bees' resistance to pesticides. More refined and economical methods for detecting glyphosate in the food supply, such as in [0,283], and in the water supply [284], need to be developed, and then applied to a variety of different food items. Most critical in our view are the vegetable oils derived from GM crops □ canola oil, soybean oil, corn oil, and cottonseed oil, as well as soy-derived protein, beet sugar, and high fructose corn syrup – ingredients that are pervasive in processed foods. Glyphosate is likely also present in meat, eggs, cheese, and other dairy products derived from animals fed glyphosate-contaminated grass, alfalfa, corn, and soy [285,286].

14. Conclusion

This paper presents an exhaustive review of the toxic effects of the herbicide, glyphosate, the active ingredient in Roundup®, in humans, and demonstrates how glyphosate's adverse effects on the gut microbiota, in conjunction with its established ability to inhibit the activity of cytochrome P450 enzymes, and its likely impairment of sulfate transport, can remarkably explain a great number of the diseases and conditions that are prevalent in the modern industrialized world. Its effects are insidious, because the long-term effects are often not immediately apparent. The pathologies to which glyphosate could plausibly contribute, through its known biosemiotic effects, include inflammatory bowel disease,

obesity, depression, ADHD, autism, Alzheimer's disease, Parkinson's disease, ALS, multiple sclerosis, cancer, cachexia, infertility, and developmental malformations. Glyphosate works synergistically with other factors, such as insufficient sun exposure, dietary deficiencies in critical nutrients such as sulfur and zinc, and synergistic exposure to other xenobiotics whose detoxification is impaired by glyphosate. Given the known toxic effects of glyphosate reviewed here and the plausibility that they are negatively impacting health worldwide, it is imperative for more independent research to take place to validate the ideas presented here, and to take immediate action, if they are verified, to drastically curtail the use of glyphosate in agriculture. Glyphosate is likely to be pervasive in our food supply, and, contrary to being essentially nontoxic, it may in fact be the most biologically disruptive chemical in our environment.

Acknowledgements

This work was funded in part by Quanta Computers, Taipei, Taiwan, under the auspices of the Qmulus Project. We thank three reviewers whose valuable comments led to a much improved version of this paper.

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Cited Reference (Samsel and Seneff 2013b)

Interdiscip Toxicol. 2013; **Vol. 6**(4): 159–184.
doi: 10.2478/intox-2013-0026
Published online in:
www.intertox.sav.sk & www.versita.com/it

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REVIEW ARTICLE

Glyphosate, pathways to modern diseases II: Celiac sprue and gluten intolerance

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ITX060413R01 • Received: 24 September 2013 • Revised: 10 November 2013 • Accepted: 12 November 2013

ABSTRACT

Celiac disease, and, more generally, gluten intolerance, is a growing problem worldwide, but especially in North America and Europe, where an estimated 5% of the population now suffers from it. Symptoms include nausea, diarrhea, skin rashes, macrocytic anemia and depression. It is a multifactorial disease associated with numerous nutritional deficiencies as well as reproductive issues and increased risk to thyroid disease, kidney failure and cancer. Here, we propose that glyphosate, the active ingredient in the herbicide, Roundup®, is the most important causal factor in this epidemic. Fish exposed to glyphosate develop digestive problems that are reminiscent of celiac disease. Celiac disease is associated with imbalances in gut bacteria that can be fully explained by the known effects of glyphosate on gut bacteria. Characteristics of celiac disease point to impairment in many cytochrome P450 enzymes, which are involved with detoxifying environmental toxins, activating vitamin D3, catabolizing vitamin A, and maintaining bile acid production and sulfate supplies to the gut. Glyphosate is known to inhibit cytochrome P450 enzymes. Deficiencies in iron, cobalt, molybdenum, copper and other rare metals associated with celiac disease can be attributed to glyphosate's strong ability to chelate these elements. Deficiencies in tryptophan, tyrosine, methionine and selenomethionine associated with celiac disease match glyphosate's known depletion of these amino acids. Celiac disease patients have an increased risk to non-Hodgkin's lymphoma, which has also been implicated in glyphosate exposure. Reproductive issues associated with celiac disease, such as infertility, miscarriages, and birth defects, can also be explained by glyphosate. Glyphosate residues in wheat and other crops are likely increasing recently due to the growing practice of crop desiccation just prior to the harvest. We argue that the practice of "ripening" sugar cane with glyphosate may explain the recent surge in kidney failure among agricultural workers in Central America. We conclude with a plea to governments to reconsider policies regarding the safety of glyphosate residues in foods.

KEY WORDS: celiac disease; gluten; glyphosate; food; cytochrome P450; deficiency

1 Introduction

Gluten intolerance is a growing epidemic in the U.S. and, increasingly, worldwide. Celiac sprue is a more specific disorder, characterized by gluten intolerance along with autoantibodies to the protein, transglutaminase, which builds crosslinks in undigested fragments of gliadin, a major constituent of gluten (Green & Cellier, 2007). The autoantibodies are produced as an immune response to undegraded fragments of proteins in gluten. A remarkable set of symptoms develop over time in association with celiac disease, including weight loss, diarrhea, chronic fatigue, neurological disorders, anemia, nausea, skin rashes, depression, and nutrient deficiencies. Usually, but not always, a strict gluten-free diet can alleviate many of the symptoms. A key associated pathology is an inflammatory response in the upper small intestine, leading to villous atrophy, a flattening of the microvilli which impairs their ability to function in their important role in absorbing nutrients.

Some have suggested that the recent surge in celiac disease is simply due to better diagnostic tools. However, a recent study tested frozen sera obtained between 1948 and 1954 for antibodies to gluten, and compared the results with sera obtained from a matched sample from people living today (Rubio-Topia *et al.*, 2009). They identified a four-fold increase in the incidence of celiac disease in the newer cohort compared to the older one. They also determined that undiagnosed celiac disease is associated with a 4-fold increased risk of death, mostly due to

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increased cancer risk. They concluded that the prevalence of undiagnosed celiac disease has increased dramatically in the United States during the past 50 years.

Transglutaminases play many important roles in the body, as they form covalent crosslinks in complex proteins in connection with blood coagulation, skin-barrier formation, extracellular matrix assembly, and fertilization, endowing the substrate with protection from degradation by proteases (Lorand & Graham, 2003). They also form crosslinks in undigested fragments of gliadin derived from wheat, and sensitivity to certain of these fragments leads to the development of autoantibodies to tissue transglutaminase (Esposito *et al.*, 2002) that inhibit its activity.

Glyphosate is the active ingredient in the herbicide Roundup. It is a broad-spectrum herbicide, considered to be nearly nontoxic to humans (Williams *et al.*, 2000). However, a recent paper (Samsel & Seneff, 2013), argued that glyphosate may be a key contributor to the obesity epidemic and the autism epidemic in the United States, as well as to several other diseases and conditions, such as Alzheimer's disease, Parkinson's disease, infertility, depression, and cancer. Glyphosate suppresses 5-enolpyruvylshikimic acid-3-phosphate synthase (EPSP synthase), the rate-limiting step in the synthesis of the aromatic amino acids, tryptophan, tyrosine, and phenylalanine, in the shikimate pathway of bacteria, archaea and plants (de María *et al.*, 1996). In plants, aromatic amino acids collectively represent up to 35% of the plant dry mass (Franz, 1997). This mode of action is unique to glyphosate among all emergent herbicides. Humans do not possess this pathway, and therefore we depend upon our ingested food and our gut microbes to provide these essential nutrients. Glyphosate, patented as an antimicrobial (Monsanto Technology LLC, 2010), has been shown to disrupt gut bacteria in animals, preferentially killing beneficial forms and causing an overgrowth of pathogens. Two other properties of glyphosate also negatively impact human health – chelation of minerals such as iron and cobalt, and interference with cytochrome P450 (CYP) enzymes, which play many important roles in the body. We will have much more to say about these aspects in later sections of this paper.

A recent study on glyphosate exposure in carnivorous fish revealed remarkable adverse effects throughout the digestive system (Senapati *et al.*, 2009). The activity of protease, lipase, and amylase were all decreased in the esophagus, stomach, and intestine of these fish following exposure to glyphosate. The authors also observed "disruption of mucosal folds and disarray of microvilli structure" in the intestinal wall, along with an exaggerated secretion of mucin throughout the alimentary tract. These features are highly reminiscent of celiac disease. Gluten peptides in wheat are hydrophobic and therefore resistant to degradation by gastric, pancreatic and intestinal proteases (Hershko & Patz, 2008). Thus, the evidence from this effect on fish suggests that glyphosate may interfere with the breakdown of complex proteins in the human stomach, leaving larger fragments of wheat in the human gut that will then trigger an autoimmune

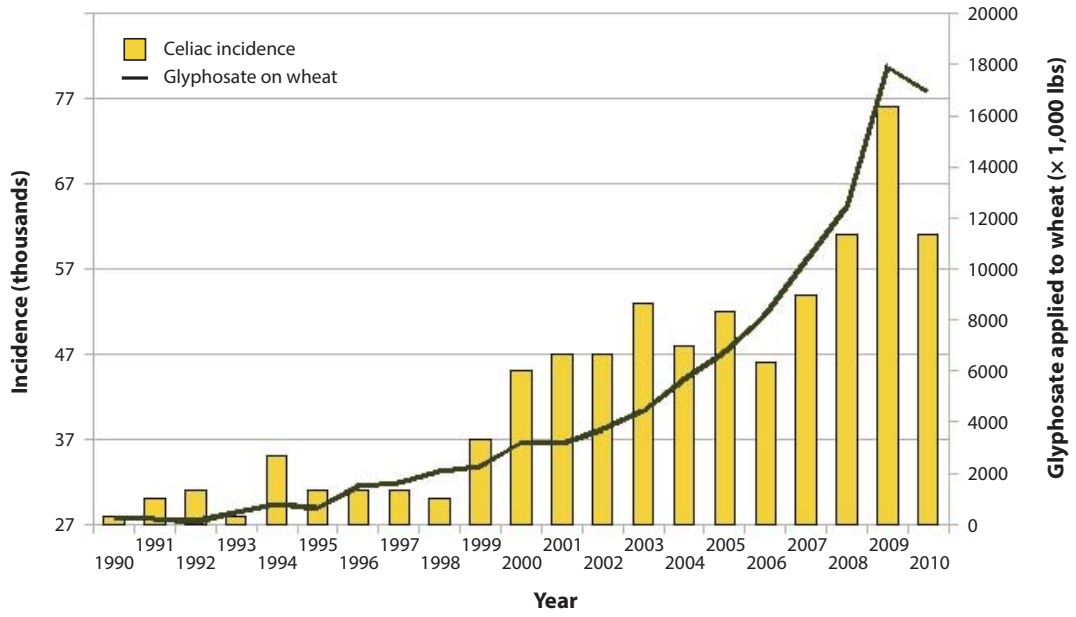

Figure 1. Hospital discharge diagnosis (any) of celiac disease ICD-9 579 and glyphosate applications to wheat (R=0.9759, $p \leq 1.862e\text{-}06$). Sources: USDA:NASS; CDC. (Figure courtesy of Nancy Swanson).

ISSN: 1337-6853 *(print version)* | 1337-9569 *(electronic version)*

Interdisciplinary Toxicology. 2013; **Vol. 6**(4): 159–184
Also available online on **PubMed Central**

response, leading to the defects in the lining of the small intestine that are characteristic of these fish exposed to glyphosate and of celiac patients. As illustrated in Figure 1, the usage of glyphosate on wheat in the U.S. has risen sharply in the last decade, in step with the sharp rise in the incidence of Celiac disease. We explain the reasons for increased application of glyphosate to wheat in Section 13.

In the remainder of this paper, we will first show that gut dysbiosis, brought on by exposure to glyphosate, plays a crucial role in the development of celiac disease. Many CYP enzymes are impaired in association with celiac disease, and we show that glyphosate's known suppression of CYP enzyme activity in plants and animals plausibly explains this effect in humans. In Section 4, we describe the role of excess retinoic acid in celiac disease, and show how this ties also to reproductive problems. We link this to the known effects of glyphosate on retinoic acid, mediated by its suppression of CYP enzymes. Section 5 addresses cobalamin deficiency, a known pathology associated with celiac disease that leads to macrocytic anemia. We argue that this follows as a direct consequence of glyphosate's ability to chelate cobalt. Section 6 discusses in more depth the role of anemia in celiac disease, a consequence of both cobalamin and iron deficiency. Section 7 discusses molybdenum deficiency and its link to microcephaly, which is associated with celiac disease. Section 8 discusses the link between selenium deficiency and autoimmune thyroid disease. Section 9 discusses kidney disease in connection with celiac disease and glyphosate. Section 10 discusses various nutritional deficiencies associated with celiac disease, and shows how these can directly be explained by glyphosate. Section 11 discusses the link between celiac disease and certain rare cancers that have also been linked to glyphosate. Section 12 goes into an in-depth discussion of how glyphosate might promote autoantibodies to transglutaminase. Following a section which presents compelling evidence that glyphosate residues in wheat, sugar and other crops are likely increasing in recent decades, and a section discussing the increased risk to kidney failure in agricultural workers exposed to excess glyphosate occupationally, we close with a discussion section that summarizes our findings, and a conclusion which implores governments to pay more attention to the damaging consequences of the escalation in chemical warfare on weeds that characterizes current agricultural practices.

2 Gut bacteria

In this section, we first discuss the role of pathogens in inducing the breakdown of tight junctions in enterocytes lining the small intestinal wall. We then show that glyphosate is associated with an overgrowth of pathogens along with an inflammatory bowel disease in animal models. A parallel exists with celiac disease where the bacteria that are positively and negatively affected by glyphosate are overgrown or underrepresented respectively in association with celiac disease in humans. We also discuss how the beneficial bacteria that are negatively impacted by glyphosate can protect from celiac disease through their enzymatic activities on gluten, and point to several articles recommending treatment plans based on probiotics.

Pathogens, through their activation of a potent signaling molecule called zonulin, induce a breakdown of the tight junctions in cells lining the gut, leading to "leaky gut" syndrome (Fasano, 2011). Concentrations of zonulin were sharply elevated ($p<0.000001$) in subjects with celiac disease during the acute phase (Fasano *et al.*, 2000). As many as 30% of celiac patients continue to experience GI symptoms after adopting a gluten-free diet, despite optimal adherence, a condition that was attributed to bacterial overgrowth in the small intestine (Tursi *et al.*, 2003). Figure 2 shows that there is a correlation between glyphosate application to wheat and the incidence of intestinal infections.

Evidence of disruption of gut bacteria by glyphosate is available for poultry (Shehata *et al.*, 2013), cattle (Krüger *et al.*, 2013), and swine (Carman *et al.*, 2013). Glyphosate disrupts the balance of gut bacteria in poultry (Shehata *et al.*, 2013), increasing the ratio of pathogenic bacteria to other commensal microbes. Salmonella and Clostridium are highly resistant to glyphosate, whereas Enterococcus, Bifidobacteria, and Lactobacillus are especially susceptible. Glyphosate was proposed as a possible factor in the increased risk to Clostridium botulinum infection in cattle in Germany over the past ten to fifteen years (Krüger *et al.*, 2013b). Pigs fed GMO corn and soy developed widespread intestinal inflammation that may have been due in part to glyphosate exposure (Carman *et al.*, 2013).

Celiac disease is associated with reduced levels of Enterococcus, Bifidobacteria and Lactobacillus in the gut and an overgrowth of pathogenic gram negative bacteria (Sanz *et al.*, 2011; Di Cagno *et al.*, 2011; Collado *et al.*, 2007). In (Di Cagno *et al.*, 2011), Lactobacillus, Enterococcus and Bifidobacteria were found to be significantly lower in fecal samples of children with celiac disease compared to controls, while levels of the pathogens, Bacteroides, Staphylococcus, Salmonella, a Shighella were elevated. In (Collado *et al.*, 2007), another study comparing the fecal material of celiac infants to healthy controls, Bacteroides, Clostridium and Staphylococcus were all found to be significantly higher ($p<0.05$). Sulfate-reducing bacterial counts were also elevated ($p<0.05$) (Nadal *et al.*, 2007; Collado *et al.*, 2007), an interesting observation which we will return to later in this paper. A significant reduction in Bifidobacteria was also found in (Nadal *et al.*, 2007). An increased excretion of the bacterial metabolites p-Cresol and phenol has also been recognized in association with celiac disease (Tamm, 1984). p-Cresol is produced via anaerobic metabolism of tyrosine by pathogenic bacteria such as Clostridium difficile (D'Ari and Barker, 1985). It is a highly toxic carcinogen, which also causes adverse effects on the central nervous system, the cardiovascular system, lungs, kidney and liver (Kelly *et al.*, 1994).

Probiotic treatments are recommended to aid in digestive healing in celiac disease. The proteolytic activity of

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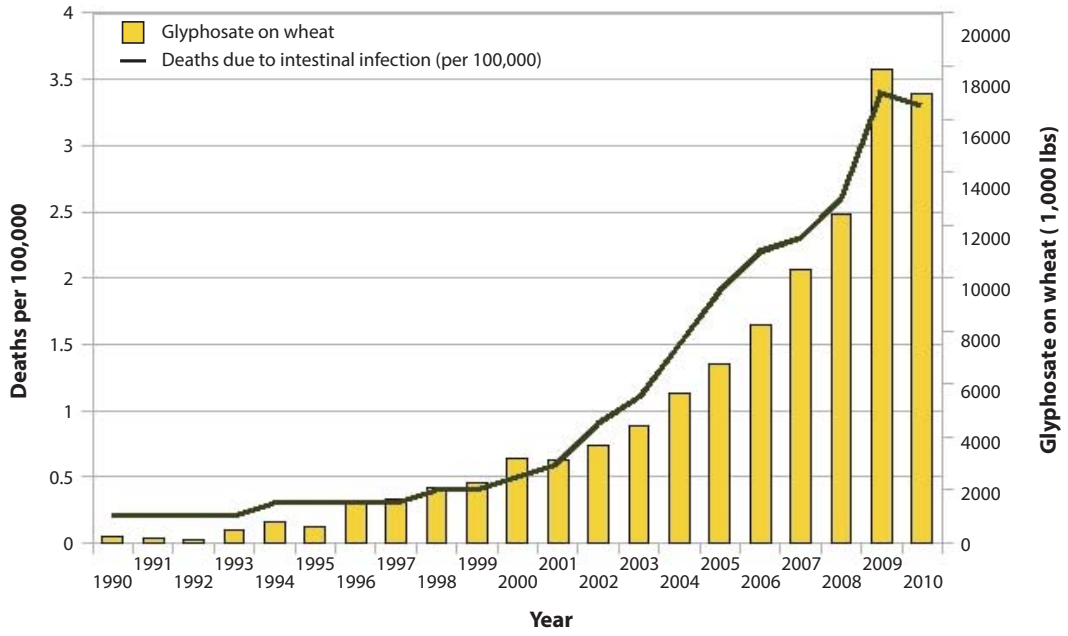

Figure 2. Deaths due to intestinal infections ICD A04, A09; 008, 009 with glyphosate applications to wheat (R=0.9834, $p \leq 3.975e\text{-}09$). Sources: USDA:NASS; CDC. (Figure courtesy of Nancy Swanson).

Lactobacilli aids the breakdown of wheat into less allergenic forms. Ongoing research aims to produce gluten-containing sourdough breads fermented by Lactobacilli that can then serve as probiotics to help ameliorate the symptoms of celiac disease and allow celiac patients to consume wheat (Gobbetti *et al.*, 2007). Probiotic Lactobacilli produce the enzyme phytase which breaks down phytates that would otherwise deplete important minerals and other cations through chelation (Famularo *et al.*, 2005). Their activities would therefore improve absorption of these micronutrients, a known problem in celiac patients (Cavallaro *et al.*, 2004). Glyphosate itself also chelates rare minerals, a subject we will address in the section on nutritional deficiencies.

Probiotic treatment with Bifidobacteria has been shown to alleviate symptoms associated with celiac disease (Smecuol *et al.*, 2013; Whorwell *et al.*, 2006). Bifidobacteria suppress the pro-inflammatory milieu triggered by the microbiota of celiac patients (Medina *et al.*, 2008). Live cultures of Bifidobacterium lactis would promote healing of the gut if offered as treatment in conjunction with the gluten-free diet, or might even allow the celiac patient to consume modest amounts of gluten without damaging effects (Lindfors *et al.*, 2008). In this in vitro study, it was demonstrated that B. lactis reduced epithelial permeability and improved the integrity of the tight junctions in human colon cells.

In summary, celiac disease is associated with a reduced presence in the gut of commensal bacteria such as Lactobacilli and Bifidobacteria, which are known to be preferentially killed by glyphosate, and with an overabundance of C. difficile, which is known to be promoted by glyphosate exposure. Bifidobacteria and Lactobacilli are both capable of modifying gluten in such a way as to make it less allergenic, a feature that is being exploited in recent efforts to develop gluten-containing foods that may be safe for consumption by celiac patients. Probiotics containing live forms of these bacteria are also being actively marketed today.

3 CYP Enzyme impairment and sulfate depletion

As mentioned previously, glyphosate has been shown to suppress CYP enzymes in plants (Lamb *et al.*, 1998) and animals (Hietanen *et al.*, 1983). A study on rats demonstrated that glyphosate decreased the levels of CYP enzymes and monooxygenase activities in the liver and the intestinal activity of aryl hydrocarbon hydroxylase (Hietanen *et al.*, 1983).

CYP enzymes are essential for detoxification of many compounds in the liver (Lindros, 1997). Intraperitoneal exposure of rats to Roundup in acute doses over a short time interval induced irreversible damage to hepatocytes and elevated urinary markers of kidney disease. This was associated with lipid peroxidation and elevated levels of the inflammatory cytokine tumor necrosis factor (TNF-α) (El-Shenawy, 2009). CYP3A is constitutively expressed in human intestinal villi and plays an important role in

ISSN: 1337-6853 *(print version)* | 1337-9569 *(electronic version)*

Interdisciplinary Toxicology. 2013; **Vol. 6**(4): 159–184
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drug metabolism (Cupp & Tracy, 1998). Celiac disease is associated with a decrease in the intestinal CYP3A (Lang *et al.*, 1996). This defect is restored by a gluten free diet.

Impaired gallbladder bile acid production (Colombato *et al.*, 1977) and biliary cirrhosis, an inflammatory liver disease characterized by obstruction of the bile duct (Dickey *et al.*, 1997), have been shown to co-occur with celiac disease. CYP enzymes are crucial in the production of bile acids (Lorbek *et al.*, 2012). An obligatory CYP enzyme in bile acid synthesis, CYP27A, has been identified as being identical to the mitochondrial vitamin D3 activating enzyme (Wikvall, 2001). In (Kemppainen *et al.*, 1999), 64% of men and 71% of women with celiac disease were found to be vitamin D3 deficient, manifested as low spinal bone mineral density. Celiac disease is associated with impaired gall bladder function and decreased pancreatic secretions (Brown *et al.*, 1987; Benini *et al.*, 2012) along with recurrent pancreatitis (Patel *et al.*, 1999). Abnormalities in bile acid secretion have been found in children suffering from celiac disease (Ejderhamn *et al.*, 1992). Celiac patients exhibit abnormally low synthesis of cholecystokinin (Deprez *et al.*, 2002), but it has also become apparent that the gall bladder is less responsive to stimulation of contraction by cholecystokinin (Brown *et al.*, 1987). A reversible defect of gallbladder emptying and cholecystokinin release has been identified in association with celiac disease (Maton *et al.*, 1985). These pathologies may be related to impaired CYP enzyme activity induced by glyphosate.

While it is clear that CYP enzymes play an important role in bile acid synthesis and in cholesterol homeostasis, the details have not yet been worked out (Lorbek *et al.*, 2012). However, some mouse knockout experiments produce embryonically lethal effects, pointing to the importance of these enzymes to biological systems. Disruption of Cyp7A1, involved in bile acid synthesis in mice, induces elevated serum cholesterol and early death.

A link has been established between celiac disease and non-alcoholic fatty liver, which is likely due to the liver's inability to export cholesterol sulfate through the bile acids due to impaired CYP enzymes (Lorbek *et al.*, 2012). This requires a private store of fats to house the excess cholesterol that cannot be exported in bile. This would also likely lead to insufficient sulfate supplies to the small intestine, and could result in impaired heparan sulfate synthesis in the glycosaminoglycans and subsequent pathologies. Heparan sulfate populating the glycosaminoglycans (GAGs) surrounding enterocytes is essential for the proper functioning of the small intestines. Leakage of both albumin and water in both the vasculature and tissues results when the negative charge is reduced due to insufficient sulfation of the polysaccharide units (Sunergren *et al.*, 1987). Vascular leakage may be a consequence of degradation of sulfated GAGs due to inflammatory agents (Klein *et al.*, 1992). A similar problem may occur in the kidneys leading to albumin loss into urine during nephrosis (Vernier *et al.*, 1983). Intestinal protein loss in inflammatory enteropathy associated with celiac disease may also be due to a deficiency in the sulfated GAGs (Murch *et al.*, 1993; Murch, 1995). A case study of three infants with congenital absence of enterocyte heparan sulfate demonstrated profound enteric protein loss with secretory diarrhoea and absorption failure, even though their intestines were not inflamed (Murch *et al.*, 1996).

In (Samsel and Seneff, 2013), a hypothesis was developed that glyphosate disrupts the transport of sulfate from the gut to the liver and pancreas, due to its competition as a similarly kosmotropic solute that also increases blood viscosity. (Kosmotropes are ions that induce "structure ordering" and "salting out" of suspended particles in colloids). Insufficient sulfate supply to the liver is a simple explanation for reduced bile acid production. The problem is compounded by impaired CYP enzymatic action and impaired cycling of bile acids through defective enterocytes in the upper small intestine. The catastrophic effect of loss of bile acids to the feces due to impaired reuptake compels the liver to adopt a conservative approach of significantly reduced bile acid synthesis, which, in turn, leads to gall bladder disease.

The protein, Nuclear factor κ-lightchain-enhancer of activated B cells (NF-κB) controls DNA transcription of hundreds of genes and is a key regulator of the immune response to infection (Tieri *et al.*, 2012). Light chains are polypeptide subunits of immunoglobulins. NF-κB responds to stimulation from bacterial and viral antigens, inflammatory cytokines like TNF-α, free radicals, oxidized LDL, DNA damage and UV light. The incidence of acute pancreatitis has been increasing in recent years (Bhatia, 2012), and it often follows billiary disease. A local inflammatory reaction at the site of injury coincides with an increase in the synthesis of hydrogen sulfide (H_2S) gas. H_2S regulates the inflammatory response by exciting the extracellular signal regulated (ERK) pathway, leading to production of NF-κB (Bhatia, 2012). We hypothesize that H_2S, while toxic, is a source of both energy and sulfate for the pancreas, derived from sulfur-containing amino acids such as cysteine and homocysteine. Dehydroepiandrosterone (DHEA) sulfate, but not DHEA, inhibits NF-κB synthesis, suggesting that sulfate deficiency is a driver of inflammation (Iwasaki *et al.*, 2004).

While H_2S is well known as a toxic gas through its inhibition of aerobic respiration, a recent paradigm shift in the research surrounding H_2S has been inspired by the realization that it is an important signaling gas in the vasculature, on par with nitric oxide (Li *et al.*, 2011). H_2S can serve as an inorganic source of energy to mammalian cells (Módis *et al.*, 2013). 3-mercaptopyruvate sulfurtransferae (3MST) is expressed in the vascular endothelium, and it produces H_2S from mercaptopyruvate, an intermediary in the breakdown of cysteine (Kimura, 2011). Endogenously produced H_2S derived from 3-mercaptopyruvate stimulates additional mitochondrial H_2S production, which then is oxidized to thiosulfate via at least three different pathways (Ingenbleek and Kimura, 2013; Hildebrandt and Grieshaber, 2008; Goubern *et al.*, 2007), producing ATP. The inflammatory agent superoxide can act as substrate for the oxidation of H_2S to sulfite and subsequently sulfate

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and the activated form, PAPS (Seneff *et al.*, 2012), but will likely induce oxidative damage in the pancreas, particularly, as we will see in section 7, if molybdenum deficiency impairs sulfite-to-sulfate synthesis.

Pancreatic beta cells express extraordinarily high levels of heparan sulfate, which is essential for their survival (Ziolkowski *et al.*, 2012), since it protects them from ROS-induced cell death. Because sulfate transport via the hepatic portal vein is likely disrupted by glyphosate, H_2S, whether derived from sulfur-containing amino acids or supplied via diffusion following its production by sulfur-reducing bacteria in the gut, can become an important source of sulfur for subsequent sulfate production locally in the pancreatic cells. Pancreatic elastase is a serine protease that is needed to assist in protein degradation, but an overabundance can lead to autolysis of tissues (Ito *et al.*, 1998). Cholesterol sulfate inhibits pancreatic elastase (Ito *et al.*, 1998), so a deficiency in cholesterol sulfate supply due to impaired sulfate supply to the liver and impaired CYP function should increase the risk of tissue digestion by pancreatic enzymes, contributing to the loss of villi in the upper small intestine observed in celiac disease.

In the early 1990's a newly recognized disease began to appear, characterized by eosinophil infiltration into the esophagus, which manifested as dysphagia in adults and refractory reflux symptoms in children (Lucendo & Sánchez-Cazalilla, 2012). This disease, termed eosinophilic esophagitis (EOE), is associated with a Th2 immune profile and synthesis of the cytokine IL-13, which has direct cytotoxic effects on epithelial cells. A dose-dependent induction of eosinophilia by intratracheal delivery of IL-13 confirms its association with EOE (Mishra and Rothenberg, 2003). An association has been found between EOE and celiac disease (Leslie *et al.*, 2010). Patients with refractory celiac disease that is not corrected by dietary gluten restriction show an increased production of IL-13 in the gut (Gross *et al.*, 2013). The incidence of EOE has increased at alarming rates in Western countries in the last three decades (Furuta *et al.*, 2007; Liacouras *et al.*, 2011; Prasad *et al.*, 2009).

Glyphosate is highly corrosive to the esophageal epidermal lining, with upper GI tract injury observed in 94% of patients following glyphosate ingestion (Chang *et al.*, 1999). In (Zouaoui *et al.*, 2013), the most common symptoms in an acute response from glyphosate poisoning were oropharyngeal ulceration, nausea and vomiting. We hypothesize that glyphosate induces EOE via a systemic response as well as through direct contact. The pathogenesis of EOE is related to food sensitivities, but airborne exposure to chemicals in the lungs can also induce it, so it does not require physical contact to the allergen (Blanchard & Rothenberg, 2008). It is conceivable that glyphosate is responsible for the emergence of EOE.

The cytochrome P450 reductase (CPR) and cytochrome P450 (CP) enzyme system is essential for inducing nitric oxide release from organic nitrates (Li, 2006). The nitrate moiety is reduced while simultaneously oxidizing NADPH to NADP+. This system is invoked in organic nitrate drug treatment for cardiovascular therapy. The reaction depends on anaerobic, acidic conditions, a feature of venous rather than arterial blood. Since L-arginine is substrate for NO synthesis by endothelial nitric oxide synthase (eNOS) under oxidative conditions (Förstermann and Münze, 2006), it is likely that CPR and CP play an important role mainly in stimulating *venous* smooth muscle relaxation. Impaired venous relaxation would likely contribute to venous thrombosis, which is a well-established complication of celiac disease (Zenjari *et al.*, 1995; Marteau *et al.*, 1994, Grigg, 1999, Halfdanarson *et al.*, 2007).

In summary, celiac disease is associated with multiple pathologies in the digestive system, including impaired gall bladder function, fatty liver, pancreatitis, and EOE. We have argued here that many of these problems can be traced to impaired CYP function in the liver due to glyphosate exposure, leading to insufficient flow of bile acids through the circular pathway between the liver and the gut. This results in a system-wide depletion in sulfate, which induces inflammation in multiple organs to produce sulfate locally. A potential sulfur source for sulfate synthesis could be hydrogen sulfide gas, provided in part by the local breakdown of sulfur-containing amino acids like cysteine and homocysteine and in part by diffusion of the gas produced from inorganic dietary sources by sulfur-reducing bacteria in the large intestine. Impaired CYP enzyme function may also contribute to venous thrombosis, for which celiac disease is an established risk factor.

4 Retinoic acid, celiac disease and reproductive issues

In this section, we first establish that excess retinoic acid (RA) is a risk factor for celiac disease. We then show that excess RA leads to complications in pregnancy and teratogenic effects in offspring. Glyphosate has been shown to exhibit teratogenic effects in line with known consequences of excess RA exposure to the embryo, and we propose that the mechanism for this effect may be glyphosate's known disruption of CYP enzymes (Samsel & Seneff, 2013), which are involved in RA catabolism. This then links glyphosate to increased risk to celiac disease via its direct effects on RA. And it identifies a possibly important factor in the association of celiac disease with reproductive issues. We also discuss other adverse effects of excess retinoic acid and a possible relationship to impaired sulfate supply to the gut.

In celiac disease, T cells develop antibody responses against dietary gluten, a protein present in wheat (Jabri & Sollid, 2009). RA, a metabolite of vitamin A, has been shown to play a critical role in the induction of intestinal regulatory responses (Mora *et al.*, 2008; Coombes *et al.*, 2007; Mucida *et al.*, 2007). The peptide in gluten, A-gliadin p31-43, induces interleukin 15 (IL-15), a key cytokine promoting T-cell activation (Hershko & Patz, 2008). RA synergizes with high levels of IL-15 to promote JNK phosphorylation (Nanda, 2011; DePaolo *et al.*, 2011), which potentiates cellular apoptosis (Putcha *et al.*, 2003).

ISSN: 1337-6853 *(print version)* | 1337-9569 *(electronic version)*

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Interdisciplinary Toxicology. 2013; **Vol. 6**(4): 159–184
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IL-15 is a causative factor driving the differentiation of precursor cells into anti-gluten CD4+ and CD8+ Th1 cells in the intestinal mucosa. Furthermore, in (DePaolo *et al.*, 2011), it was discovered that RA exhibits an unanticipated co-adjuvant property to induce Th1 immunity to antigens during infection of the intestinal mucosa with pathogens. Retinoic acid has also been shown to directly suppress transglutaminase activity, another way in which it would negatively impact celiac disease (Thacher *et al.*, 1985). Thus, it is becoming clear that excess exposure to RA would increase risk to celiac disease, and warnings have been issued regarding potential adverse effects of RA supplements on celiac disease.

It is well established that high RA levels leads to teratogenic effects both in human and experimental models. Brain abnormalities such as microcephaly, impairment of hindbrain development, mandibular and midfacial underdevelopment, and cleft palate are all implicated (Sulik *et al.*, 1988; Clotman *et al.*, 1998). Women with celiac disease are known to have higher rates of infertility, miscarriages, and birth defects in their offspring (Freeman, 2010; Martinelli *et al.*, 2000; Dickey *et al.*, 1996; Collin *et al.*, 1996). Excess RA could be a significant factor in these complications.

A possible mechanism by which glyphosate might induce excess RA is via its interference with the CYP enzymes that metabolize RA. There are at least three known CYPs (CYP26A1, CYP26B1 and CYP26C1) that catabolize RA, and they are active in both the embryo and the adult (Taimi *et al.*, 2004). A 1/5000 dilution of glyphosate was sufficient to induce reproducible malformations characteristic of RA exposure in frog embryos (Paganelli *et al.*, 2010). Pathologies included shortening of the trunk, reduction in the size of the head, abnormally small eyes or the presence of only one eye (cyclopia), and other craniofacial malformations in the tadpole. Glyphosate's toxicity to tadpoles has been well demonstrated, as it killed nearly 100% of larval amphibians exposed in experimental outdoor pond mesocosms (Relyea, 2005).

According to official records, there has been a recent 4-fold increase in developmental malformations in the province of Chaco, Argentina, where glyphosate is used massively on GMO monocrops of soybeans (Carrasco, 2013). In Paraguay, 52 cases of malformations were reported in the offspring of women exposed during pregnancy to agrochemicals, including anencephaly, microcephaly, facial defects, cleft palate, ear malformations, polydactily, and syndactily (Benítez-Leite *et al.*, 2009). In in vitro studies on human cell lines, DNA strand breaks, plasma membrane damage and apoptosis were observed following exposure to glyphosate-based herbicides (Gasnier *et al.*, 2009). Another factor in teratogenetic effects of glyphosate may be the suppression of the activity of androgen-to-estrogen conversion by aromatase, a CYP enzyme (Gasnier *et al.*, 2009).

Ingested vitamin A, a fat-soluble vitamin, is delivered to the blood via the lymph system in chylomicrons, and excess vitamin A is taken up by the liver as retinoic acid for catabolism by CYP enzymes (Russell, 2000). Any remaining retinoic acid that is not catabolized is exported inside LDL particles, and it lingers much longer as retinyl esters in the vasculature in this form (Krasinski *et al.*, 1990). Excess retinoic acid is more readily stored in this way in LDL particles in the elderly. Vitamin A toxicity can lead to fatty liver and liver fibrosis (Russell, 2000) as well as hypertriglyceridemia (Ellis *et al.*, 1986). Vitamin A has a negative effect on cholesterol sulfate synthesis (Jetten *et al.*, 1989), which might negatively impact the liver's ability to maintain adequate supplies of cholesterol sulfate for the bile acids, and therefore also interfere with the supply of cholesterol sulfate to the gastrointestinal tract.

In summary, glyphosate's disruption of the CYP enzymes responsible for RA catabolism could lead to an excess bioavailability of RA that could contribute adversely to celiac disease, as well as damaging the liver and leading to teratogenic effects in offspring of exposed individuals.

In addition to higher risk to birth defects, individuals with celiac disease have increased risk to infertility (Meloni *et al.*, 1999; Farthing *et al.*, 1982). Increased incidence of hypogonadism, infertility and impotence was observed in a study of 28 males with celiac disease (Farthing *et al.*, 1982). Marked abnormalities of sperm morphology and motility were noted, and endocrine dysfunction was suggested as a probable cause. In studies conducted on Sertoli cells in prepubertal rat testis, exposure to Roundup induced oxidative stress leading to cell death (de Liz Oliveira Cavalli *et al.*, 2013). Roundup induced the opening of L-type voltage dependent calcium channels as well as ryanodine receptors, initiating ER stress and leading to calcium overload and subsequent necrosis. Glutathione was depleted due to upregulation of several glutathione-metabolizing enzymes. This suggests that Roundup would interfere with spermatogenesis, which would impair male fertility.

5 Cobalamin deficiency

Untreated celiac disease patients often have elevated levels of homocysteine, associated with folate and/or cobalamin deficiency (Saibeni *et al.*, 2005; Dickey *et al.*, 2008). Species of Lactobacillus and Bifidobacterium have the capability to biosynthesize folate (Rossi *et al.*, 2011), so their disruption by glyphosate could contribute to folate deficiency. Malabsorption in the proximal small intestine could also lead to iron and folate deficiencies. Cobalamin was originally thought to be relatively spared in celiac disease because its absorption is mostly through the terminal ileum, which is unaffected by celiac disease. However, a recent study found that cobalamin deficiency is prevalent in celiac patients. 41% of the patients studied were found to be deficient in cobalamin (<220 ng/L), and 31% of these cobalamin-deficient patients also had folate deficiency (Dahele & Ghosh, 2001). Either cobalamin or folate deficiency leads directly to impaired methionine synthesis from homocysteine, because these two vitamins are both required for the reaction to take place. This induces

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hyperhomocysteinemia (Refsum *et al.*, 2001), an established risk factor in association with celiac disease (Hadithi *et al.*, 2009). Long-term cobalamin deficiency also leads to neurodegenerative diseases (Herrmann & Obeid, 2012).

Because a deficiency in cobalamin can generate a large pool of methyl-tetrahydrofolate that is unable to undergo reactions, cobalamin deficiency will often mimic folate deficiency. Cobalamin requires cobalt, centered within its corrin ring, to function. We depend upon our gut bacteria to produce cobalamin, and impaired cobalt supply would obviously lead to reduced synthesis of this critical molecule. Glyphosate is known to chelate +2 cations such as cobalt. Glyphosate complexes with cobalt as a dimer [Co(glyphosate)2]3 in fifteen different stereoisomeric configurations, and it is facile at switching among the different stereoisomers, an unusual kinetic property compared to most Co(III) systems (Cusiel, 2005).

In fact, studies have revealed that glyphosate inhibits other cytosolic enzymes besides EPSP synthase in plants and microbes that also activate steps in the shikimate pathway (Ganson and Jensen, 1988; Bode *et al.*, 1984). Glyphosate potently inhibits three enzymes in the shikimate pathway in yeast (Bode *et al.*, 1984). It has been confirmed that these other enzymes depend upon cobalt as a catalyst, and glyphosate inhibition works through competitive cobalt binding and interference with cobalt supply (Ganson and Jensen, 1988). It has also been proposed that chelation by glyphosate of both cobalt and magnesium contributes to impaired synthesis of aromatic amino acids in Escherichia coli bacteria (Hoagland and Duke, 1982). Thus, it is plausible that glyphosate similarly impairs cobalamin function in humans by chelating cobalt.

6 Anemia and iron

Anemia is one of the most common manifestations of celiac disease outside of the intestinal malabsorption issues (Halfdanarson *et al.*, 2007; Bottaro *et al.*, 1999), and is present in up to half of diagnosed celiac patients. Celiac patients often have both cobalamin and folate deficiency, which can cause anemia, but iron deficiency may be the most important factor (Hershko & Patz, 2008). Celiac patients often don't respond well to iron treatment.

Glyphosate's chelating action can have profound effects on iron in plants (Eker *et al.*, 2006; Bellaloui *et al.*, 2009). Glyphosate interferes with iron assimilation in both glyphosate-resistant and glyphosate-sensitive soybean crops (Bellaloui *et al.*, 2009). It is therefore conceivable that glyphosate's chelation of iron is responsible for the refractory iron deficiency present in celiac disease.

Erythropoietin (EPO), also called hematopoietin, is a cytokine produced by interstitial fibroblasts in the kidney that regulates red blood cell production. Low EPO levels, leading to a low turnover rate of red blood cells, is a feature of celiac disease (Bergamaschi *et al.*, 2008; Hershko & Patz, 2008). This can lead to megaloblastic anemia, where red blood cells are large (macrocytic) and reduced in number due to impaired DNA synthesis. A recent hematological study on mice exposed to Roundup at subacute levels for just 15 days revealed an anemic syndrome in both male and female mice, with a significant reduction in the number of erythrocytes and in hemoglobin, reduced hematocrit and increased mean corpuscular volume, indicative of macrocytic anemia (Jasper *et al.*, 2012).

7 Molybdenum deficiency

Molybdenum deficiency is rarely considered in diagnoses, as it is only needed in trace amounts. However, molybdenum is essential for at least two very important enzymes: sulfite oxidase and xanthine oxidase. Sulfite oxidase converts sulfite, a highly reactive anion, to sulfate, which is much more stable. Sulfite is often present in foods such as wine and dried fruits as a preservative. Sulfate plays an essential role in the sulfated proteoglycans that populate the extracellular matrices of nearly all cell types (Turnbull *et al.*, 2001; Murch *et al.*, 1993; Murch, 1995). So, impaired sulfite oxidase activity leads to both oxidative damage and impaired sulfate supplies to the tissues, such as the enterocytes in the small intestine. The excess presence of sulfur-reducing bacteria such as Desulfovibrio in the gut in association with celiac disease (Collado *et al.*, 2007; Nadal *et al.*, 2007) could be protective, because these bacteria can reduce dietary sulfite to hydrogen sulfide, a highly diffusable gas that can migrate through tissues to provide a source of sulfur for sulfate regeneration at a distant site, as previously discussed. These distal sites could reoxidize the H_2S through an alternative pathway that does not require molybdenum for sulfur oxidation (Ingenbleek and Kimura, 2013).

Xanthine oxidase (XO) produces uric acid from xanthine and hypoxanthine, which are derived from purines. It is activated by iron, which, as we have seen, is often intractably deficient in association with celiac disease. Impaired XO activity would be expected to drive purines towards other degradation pathways. Adenosine deaminase (ADA), a cytoplasmic enzyme that is involved in the catabolism of purine bases, is elevated in celiac disease, and is therefore a useful diagnostic marker (Cakal *et al.*, 2010). In fact, elevation of ADA is correlated with an increase in several inflammatory conditions. Impaired purine synthesis is expected in the context of cobalamin deficiency as well, because methyl melonlyl CoA mutase depends on catalytic action by cobalamin (Allen *et al.*, 1993). Decreased purine synthesis results in impaired DNA synthesis, which then leads to megaloblastic anemia (Boss, 1985), due to slowed renewal of RBC's from multipotent progenitors, a problem that is compounded by suppressed EPO activity (Bergamaschi *et al.*, 2008), a feature of celiac disease.

A remarkable recent case of a three-month old infant suffering from molybdenum deficiency links several aspects of glyphosate toxicity together, although glyphosate exposure was not considered as a possible cause in this case (Boles *et al.*, 1993). This child presented with microcephaly, developmental delay, severe irritability,

ISSN: 1337-6853 *(print version)* | 1337-9569 *(electronic version)*

Interdisciplinary Toxicology. 2013; **Vol. 6**(4): 159–184
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and lactic acidosis. Lactic acidosis is a striking feature of intentional glyphosate poisoning induced by drinking Roundup (Zouaoui *et al.*, 2013; Beswick & Millo, 2011), and it suggests impaired oxidative respiration, as is seen in E. coli exposed to glyphosate (Lu *et al.*, 2013). In vitro studies of glyphosate in the formulation Roundup have demonstrated an ability to disrupt oxidative respiration by inducing mitochondrial swelling and inhibiting mitochondrial complexes II and III (Peixoto, 2005). This would explain a massive build-up of lactic acid following ingestion of Roundup, due to a switch to anaerobic metabolism. Glyphosate has also been shown to uncouple mitochondrial phosphorylation in plants (Haderly *et al.*, 1977; Ali & Fletcher, 1977).

As has been stated previously, microcephaly is a feature of excess RA, which could be induced by glyphosate due to its inhibitory action on CYP enzymes. In the case study on molybdenum deficiency (Boles *et al.*, 1993), urinary sulfite levels were high, indicative of defective sulfite oxidase activity. Serum hypouricemia was also present, indicative of impaired XO activity. So, the induction of excess RA, depletion of molybdenum, and lactic acidosis by glyphosate provide a plausible environmental factor in this case.

One final aspect of molybdenum deficiency involves nitrate metabolism. As a source of nitric oxide, inorganic nitrite regulates tissue responses to ischemia. While nitrate reductase activity has been known to be a capability of microbes for many years, it has only recently been realized that mammals also possess a functioning nitrate reductase capability, utilizing a molybdenum-dependent enzyme to produce nitrite from nitrate (Jansson *et al.*, 2008). Molybdenum deficiency would impair this capability, likely contributing to the higher risk to venous thrombosis observed in celiac disease (Zenjari *et al.*, 1995; Marteau *et al.*, 1994, Grigg, 1999). This could also explain the excess nitrates in the urine observed in association with celiac disease (Högberg *et al.*, 2011).

8 Selenium and thyroid disorders

Autoimmune thyroid disease is associated with celiac disease (Collin *et al.*, 2002; Valentino *et al.*, 2002). In (Valentino *et al.*, 2002), up to 43% of patients with Hashimoto's thyroiditis showed signs of mucosal T-cell activation typical of celiac disease. Selenium, whose deficiency is associated with celiac disease (Hinks *et al.*, 1984), plays a significant role in thyroid hormone synthesis, secretion and metabolism, and selenium deficiency is therefore a significant factor in thyroid diseases (Sher, 2000; Chanoine *et al.*, 2001; Khrle, 2013).

Selenium is required for the biosynthesis of the "twenty first amino acid," selenocysteine. Twenty five specific selenoproteins are derived from this amino acid. Selenium deficiency can lead to an impairment in immune function and spermatogenesis in addition to thyroid function (Papp *et al.*, 2007). One very important selenoprotein is glutathione peroxidase, which protects cell membranes and cellular components against oxidative damage by both hydrogen peroxide and peroxynitrite ($ONOO^-$) (Prabhakar *et al.*, 2006).

Wheat can be a good source of selenoproteins. However, the content of selenium in wheat can range from sufficient to very low, depending upon soil physical conditions. Soil compaction, which results from modern practices of "no till" agriculture (Huggins & Reganold, 2008), can lead to both reduced selenium content and a significant increase in arsenic content in the wheat (Zhao *et al.*, 2007). Since glyphosate has been shown to deplete sulfur in plants (Saes Zobiole *et al.*, 2010), and selenium is in the same column of the periodic table as sulfur, it is likely that glyphosate also disrupts selenium uptake in plants. A gluten-free diet will guarantee, however, that no selenium is available from wheat, inducing further depletion of selenoproteins, and therefore increasing the risk to immune system, thyroid and infertility problems in treated celiac patients.

The gut bacterium Lactobacillus, which is negatively impacted by glyphosate (Shehata *et al.*, 2013) and depleted in association with celiac disease (Di Cagno *et al.*, 2011), is able to fix inorganic selenium into more bioavailable organic forms like selenocysteine and selenomethionine (Pessione, 2012). Selenocysteine is present in the catalytic center of enzymes that protect the thyroid from free radical damage (Triggiani *et al.*, 2009). Free radical damage would lead to apoptosis and an autoimmune response (Tsatsoulis, 2002). Glyphosate's disruption of these bacteria would lead to a depletion in the supply of selenomethionine and selenocysteine. Methionine depletion by glyphosate (Nafziger *et al.*, 1984) would further compound this problem.

Thus, there are a variety of ways in which glyphosate would be expected to interfere with the supply of selenoproteins to the body, including its effects on Lactobacillus, its depletion of methionine, the no-till farming methods that are possible because weeds are killed chemically, and the likely interference with plant uptake of inorganic selenium. This aligns well with the observed higher risk of thyroid problems in association with celiac disease, in addition to infertility problems and immune issues, which are discussed elsewhere in this paper. Further support for an association between glyphosate and thyroid disease comes from plots over time of the usage of glyphosate in the U.S. on corn and soy time-aligned with plots of the incidence rate of thyroid cancer in the U.S., as shown in Figure 3.

9 Indole and kidney disease

The prevalence of kidney disease and resulting dialysis is increasing worldwide, and kidney disease is often associated with increased levels of celiac disease autoantibodies. Kidney disease and thyroid dysfunction are intimately connected (Iglesias & Díez, 2009). A population-based study in Sweden involving nearly 30,000 people with diagnosed celiac disease determined that there was nearly a three-fold increased risk for kidney failure in this population group (Welander *et al.*, 2012).

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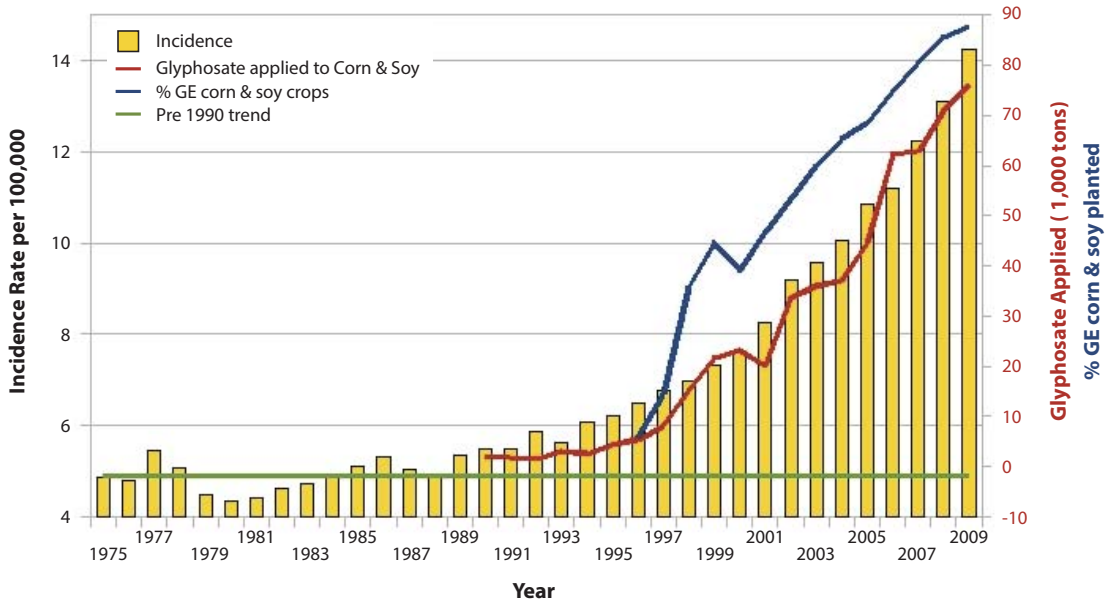

Figure 3. Thyroid cancer incidence rate plotted against glyphosate applied to U.S. corn & soy crops (R=0.988, $p \leq 7.612e\text{-}09$) along with %GE corn & soy crops (R=0.9377, $p \leq 2.152e\text{-}05$). Sources: USDA:NASS; SEER. (Figure courtesy of Nancy Swanson).

Inflammation plays a crucial role in kidney disease progression (Tonelli *et al.*, 2005; Bash *et al.*, 2009; Rodriguez-Iturbe *et al.*, 2010). Chronic kidney disease develops as a consequence of assaults on the kidney from inflammatory agents, brought on by the induction of pro-inflammatory cytokines and chemokines in the kidney. The toxic phenol p-Cresol sulfate, as well as indoxyl sulfate, a molecule that is chemically similar to p-Cresol, have been shown to induce activation of many of these cytokines and chemokines (Sun *et al.*, 2012). p-Cresol and indoxyl sulfate both decrease endothelial proliferation and interfere with wound repair (Dou *et al.*, 2004). p-Cresol is produced by the pathogenic bacterium C. difficile, and indoxyl sulfate, derived from indole through sulfation in the liver (Banoglu & King, 2002), accumulates at high levels in association with chronic kidney disease (Niwa, 2010).

The aromatic amino acid tryptophan contains an indole ring, and therefore disruption of tryptophan synthesis might be expected to generate indole as a by-product. Indeed, glyphosate has been shown to induce a significant increase in the production of indole-3-acetic acid in yellow nutsedge plants (Caal *et al.*, 1987). Indole is produced by coliform microorganisms such as E. coli under anaerobic conditions. Glyphosate induces a switch in E. coli from aerobic to anaerobic metabolism due to impaired mitochondrial ATP synthesis (Lu *et al.*, 2013; Samsel & Seneff, 2013), which would likely result in excess production of indole. Besides, E. coli, many other pathogenic bacteria can produce indole, including Bacillus, Shigella, Enterococcus, and V. cholerae (Lee & Lee, 2010). At least 85 different species of both Gram-positive and Gram-negative bacteria produce indole, and its breakdown by certain bacterial species depends on CYP enyzmes (Lee & Lee, 2010). Feeding indole to rats deprived of sulfur metabolites leads to macrocytic anemia (Roe, 1971). Indole is an important biological signaling molecule among microbes (Lee & Lee, 2010). Indole acetic acid inhibits the growth of cobalamin-dependent microorganisms, which then causes macrocytic (pernicious) anemia in the host due to cobalamin deficiency (Drexler, 1958).

Experiments on exposure of mouse fetuses to indole-3-acetic acid have shown that it dramatically induces microcephaly in developing fetuses exposed at critical times in development (Furukawa *et al.*, 2007). A case study found celiac disease associated with microcephaly and developmental delay in a 15-month-old girl (Bostwick *et al.*, 2001; Lapunzina, 2002). A gluten-free diet restored head growth. The authors suggested that poor head growth might precede other manifestations of celiac disease in infants. A study on plants demonstrated a concentration gradient of indole-3-acetic acid in the plant embryo, similar to the gradient in retinoic acid that controls fetal development in mammals (Uggla *et al.*, 1996). This alternative may be another way in which glyphosate would promote microcephaly.

Thus, solely through its effect on indole production and indole catabolism in gut bacteria, chronic glyphosate exposure would be expected to lead to cobalamin deficiency, pernicious anemia, microcephaly in a fetus during pregnancy, and kidney failure. p-Cresol supply by overgrown pathogens like C. difficile would likely contribute in a similar way as indole, due to its similar biochemical and biophysical properties.

ISSN: 1337-6853 *(print version)* | 1337-9569 *(electronic version)*

Interdisciplinary Toxicology. 2013; **Vol. 6**(4): 159–184
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10 Nutritional deficiencies

The damaged villi associated with celiac disease are impaired in their ability to absorb a number of important nutrients, including vitamins B6, B12 (cobalamin) and folate, as well as iron, calcium and vitamins D and K (Hallert *et al.*, 2002). Thus, long-term celiac disease leads to major deficiencies in these micronutrients. Cobalamin deficiency has been well addressed previously. We have also already mentioned the chelation of trace minerals by phytates and by glyphosate. However, other factors may be at play as well, as discussed here.

Glyphosate disrupts the synthesis of tryptophan and tyrosine in plants and in gut bacteria, due to its interference with the shikimate pathway (Lu *et al.*, 2013; María *et al.*, 1996), which is its main source of toxicity to plants. Glyphosate also depletes methionine in plants and microbes. A study on serum tryptophan levels in children with celiac disease revealed that untreated children had significantly lower ratios of tryptophan to large neutral amino acids in the blood, and treated children also had lower levels, but the imbalance was less severe (Hernanz & Polanco, 1991). The authors suggested a metabolic disturbance in tryptophan synthesis rather than impaired absorption, as other similar amino acids were not deficient in the serum. It was proposed that this could lead to decreased synthesis of the monoamine neurotransmitter, serotonin, in the brain associated with behavior disorders in children with celiac disease, such as depression (Koyama & Melzter, 1986). Deficiencies in tyrosine and methionine were also noted (Hernanz & Polanco, 1991). "Functional dyspepsia" is an increasing and mainly intractable problem in the Western world, which is estimated to affect 15% of the U.S. population (Saad & Chey, 2006). Dyspepsia, a clinical symptom of celiac disease, is likely mediated by excess serotonin synthesis following ingested tryptophan-containing foods (Manocha *et al.*, 2012).

Serotonin (5-hydroxytryptamine or 5-HT) is produced by enterochromaffin (EC) cells in the gut and is an important signaling molecule for the enteric mucosa (Kim *et al.*, 2001). EC cells are the most numerous neuroendocrine cell type in the intestinal lumen, and they regulate gut secretion, motility, pain and nausea by activating primary afferent pathways in the nervous system (Chin *et al.*, 2012). Serotonin plays an important role in activating the immune response and inflammation in the gut, and also induces nausea and diarrhea when it is overexpressed. Anaerobic bacteria in the colon convert sugars into short-chain fatty acids, which can stimulate 5-HT release from EC cells (Fukumoto *et al.*, 2003; Grider & Piland, 2007). This is likely an important source of fats to the body in the case of a low-fat diet induced by impaired fatty acid metabolism due to insufficient bile acids.

The number of 5-HT expressing EC cells in the small intestine is increased in association with celiac disease, along with crypt hyperplasia (Wheeler & Challacombe, 1984; Challacombe *et al.*, 1977), and, as a consequence, serotonin uptake from dietary sources of tryptophan is greatly increased in celiac patients (Erspamer, 1986). Postprandial dyspepsia is associated in celiac disease with increased release of 5-HT, and this may account for the digestive symptoms experienced by celiac patients (Coleman *et al.*, 2006). An explanation for these observations is that a chronic tryptophan insufficiency due to the impaired ability of gut bacteria to produce tryptophan induces aggressive uptake whenever dietary tryptophan is available.

Glyphosate forms strong complexes with transition metals, through its carboxylic, phosphonic, and amino moieties, each of which can coordinate to metal ions, and it can also therefore form complexes involving two or three atoms of the targeted transition metal (Madsen *et al.*, 1978; Motekaitis & Martell, 1985; Undabeytia *et al.*, 2002). This means that it is a metal chelator par excellence. One can expect, therefore, deficiencies in multiple transition (trace) metals, such as iron, copper, cobalt, molybdenum, zinc and magnesium in the presence of glyphosate. Glyphosate has been shown to reduce levels of iron, magnesium, manganese and calcium in non-GMO soybean plants (Cakmak *et al.*, 2009). We have already discussed iron, selenium, cobalt and molybdenum deficiencies in association with celiac disease.

Zinc deficiency seems to be a factor in celiac disease, as a recent study of 30 children with celiac disease demonstrated a significantly reduced serum level of zinc (0.64 vs 0.94 μg/mL in controls) (Singhal *et al.*, 2008). Copper deficiency is a feature of celiac disease (Halfdanarson *et al.*, 2009), and copper is one of the transition metals that glyphosate binds to and chelates (Madsen, 1978; Undabeytia, 2002). Confirmed magnesium deficiency in celiac disease has been shown to be due to significant loss through the feces (Goldman *et al.*, 1962). This would be expected through binding to phytates and/or glyphosate. A study of 23 patients with gluten-sensitive enteropathy to assess magnesium status revealed that only one had *serum* magnesium levels below the normal range, whereas magnesium levels in *erythrocytes* and *lymphocytes* was markedly below normal, and this was associated with evidence of osteoporosis due to malabsorption (Rude and Olerich, 1996). Daily treatment with $MgCl_2$ or Mg lactate led to a significant increase in bone mineral density, and was correlated with a rise in RBC Mg^{2+}.

A recent study investigated the status of 25(OH) vitamin D3 in adults and children with celiac disease (Lerner *et al.*, 2012). It was determined that vitamin D3 deficiency was much more prevalent in the adults than in the children, suggesting a deterioration in vitamin D3 serum levels with age. This could be explained by a chronic accumulation of glyphosate, leading to increasingly impaired vitamin D3 activation in the liver. The liver converts 1,25(OH) vitamin D3 to the active form, 25(OH) vitamin D3, using CYP27A (Ponchon *et al.*, 1969; Sakaki *et al.*, 2005), which might be disrupted by glyphosate exposure, given its known interference with CYP function in mice (Hietanen *et al.*, 1983). On a broader level, this might also explain the recent epidemic in the U.S. in vitamin D3 deficiency (Holick, 2005).

Another issue to consider is whether the food being consumed by celiac patients is itself depleted in nutrients.

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This is likely the case for the transgenic Roundup-Ready crops that increasingly supply the processed food industry. A recent study on the effects of glyphosate on Roundup-Ready soy revealed a significant effect on growth, as well as an interference with the uptake of both macronutrients and micronutrients (Saes Zobiole *et al.*, 2010). Transgenic soybeans exposed to glyphosate are often affected by a "yellow flashing" or yellowing of the upper leaves, and an increased sensitivity to water stress. An inverse linear relationship was observed between glyphosate dosage and levels of the macronutrients, sodium, calcium, sulfur, phosphorus, potassium, magnesium, and nitrogen, as well as the micronutrients, iron, zinc, manganese, copper, cobalt, molybdenum, and boron. Glyphosate's ability to form insoluble metal complexes likely mediates these depletions (Glass, 1984). Glyphosate also interferes with photosynthesis, as reflected in several measures of photosynthesis rate (Saes *et al.*, 2010) and reductions in chlorophyll (Ali & Fletcher, 1977; Kitchen *et al.*, 1981). This could be due to depletion of zinc and manganese, since chloroplasts require these micronutrients to function well (Homann, 1967; Thompson & Weier, 1962).

11 Cancer

Chronic inflammation, such as occurs in celiac disease, is a major source of oxidative stress, and is estimated to account for 1/3 of all cancer cases worldwide (Ames *et al.*, 1993; Coussens & Werb, 2002). Oxidative stress leads to DNA damage and increased risk to genetic mutation. Several population-based studies have confirmed that patients with celiac disease suffer from increased mortality, mainly due to malignancy (Nielsen *et al.*, 1985; Logan *et al.*, 1989; Pricolo *et al.*, 1998; Cottone *et al.*, 1999; Corrao *et al.*, 2001; Green *et al.*, 2003). These include increased risk to non-Hodgkin's lymphoma, adenocarcinoma of the small intestine, and squamous cell carcinomas of the esophagus, mouth, and pharynx, as well as melanoma. The non-Hodgkin's lymphoma was not restricted to gastrointestinal sites, and the increased risk remained following a gluten-free diet (Green *et al.*, 2003).

Celiac disease is associated with a lifelong risk of any malignancy between 8.1 and 13.3%, with the risk for non-Hodgkin's lymphoma alone being 4.3 to 9.6% (Matheus-Vliezen *et al.*, 1994; Egan *et al.*, 1995). This risk is 19-fold higher than the risk in the general population. Selenium deficiency in association with celiac disease may be a significant factor in the increased cancer risk. Selenium deficiency is associated with increased risk to several cancers, and selenium supplements are beneficial in reducing the incidence of liver cancer and decreasing mortality in colorectal, lung and prostate cancer (Nelson *et al.*, 1999; Björnstedt *et al.*, 2010).

Children with celiac disease, whether or not they are on a gluten-free diet, exhibit elevated urinary biomarkers of DNA damage (Zaflarska-Popawska *et al.*, 2010). Human colon carcinoma cells exposed to peptides extracted from wheat responded with a sharp increase in the GSSG/GSH ratio (ratio of oxidized to reduced glutathione), a well-established indicator of oxidative stress (Rivabene, 1999). The authors did not provide information as to whether the wheat plants were exposed to glyphosate, but they did suggest that this effect could explain the increased risk to intestinal cancer associated with celiac. Intriguingly, studies on pea plants have shown that *glyphosate* induces a sharp increase in the GSSG/GSH ratio in plants (Miteva *et al.*, 2003), which suggests that glyphosate contamination could explain the results observed in (Rivabene, 1999).

Interestingly, it was noted in 1996 that the incidence of both non-Hodgkin's lymphoma and melanoma had been rising sharply worldwide in recent decades, and so it was decided to investigate whether there might be a link between the two cancers associated with sunlight exposure. Surprisingly, the authors found an *inverse* relationship between non-Hodgkin's lymphoma and UV exposure. More recently, such UV protection has been reaffirmed in a review of epidemiologic studies on the subject (Negri, 2010). This suggests that vitamin D3 is protective, so vitamin D3 deficiency due to impaired CYP function in the liver could be contributory to increased risk in celiac disease.

The incidence of non-Hodgkins lymphoma has increased rapidly in most Western countries over the last few decades. Statistics from the American Cancer Society show an 80% increase since the early 1970's, when glyphosate was first introduced on the market.

While there have been only a few studies of lymphoma and glyphosate, nearly all have indicated a potential relationship (Vigfusson & Vyse, 1980; Pavkov & Turnier, 1986; Hardell & Eriksson, 1999; McDuffie *et al.*, 2001; De Roos *et al.*, 2003). A dose-response relationship for non-Hodgkin's lymphoma was demonstrated in a cross-Canada study of occupational exposure to glyphosate in men (McDuffie *et al.*, 2001), and a larger study in the U.S. noted a similar result (De Roos *et al.*, 2003). A population-based study in Sweden showed an increased risk to non-Hodgkins lymphoma upon prior exposure to herbicides and fungicides but not insecticides (Hardell & Eriksson, 1999). Glyphosate exposure resulted in an odds ratio of 2.3, although the number of samples was small, and the authors suggested that further study is necessary. A study on mice showed increases in carcinoma, leukemia and lymphoma (Pavkov & Turnier, 1986) and an in vitro mutagenic test on human lymphocytes revealed increased sister-chromatid exchanges (Vigfusson & Vyse, 1980) upon exposure to glyphosate.

12 Proposed transglutaminase-glyphosate interactions

Establishing the mechanism by which glyphosate might promote autoantibodies to transglutaminase is a challenging task, not because this possibility seems unlikely but rather because multiple disruptions are plausible. In this section, we present evidence from the research literature that supports various hypotheses for the interaction

ISSN: 1337-6853 *(print version)* | 1337-9569 *(electronic version)*

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Interdisciplinary Toxicology. 2013; **Vol. 6**(4): 159–184
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of glyphosate with the transglutaminase enzymatic pathways. The definitive studies that clarify which of these hypotheses is correct have yet to be conducted.

Celiac disease is thought to be primarily caused by ingestion of wheat gluten proteins, particularly gliadin, due to a high concentration of proline- and glutamine-rich sequences, which imparts resistance to degradation by proteases. Transglutaminase autoimmunity arises when specific epitopes of wheat gliadin activate sensitized T-cells which then stimulate B-cell synthesis of IgA or IgM autoantibodies to transglutaminase. Transglutaminase bound to gliadin can induce false recognition by a T-cell.

Transglutaminase acts on gluten in wheat to form crosslinks between glutamine residues and lysine residues, producing ammonia as a by-product. Ammonia is known to induce greater sensitivity to glyphosate in plants, and it is common practice to apply ammonium sulfate simultaneously with glyphosate for this reason (Nalewaja & Matysiak, 1993). This enhanced effect is due to ammonium binding to glyphosate at three sites – one on the carbonyl group and two on the phosphonyl group, which displaces cations such as calcium and endows glyphosate with enhanced reactivity.

Transglutaminase sometimes only achieves half of its intended reaction product, by converting a glutamine residue to glutamate, and leaving lysine intact, thus not producing the desired crosslink. It has been established that gluten fragments containing "deamidated glutamine" residues instead of the crosslinks are much more highly allergenic than those that contain the crosslinks (Dørum *et al.*, 2010; Qiao *et al.*, 2005). These have been referred to as "celiac disease T-Cell epitopes." T-cells of celiac patients preferentially recognize epitopes that are augmented with negatively charged deamidated glutamine residues – the product of the reaction when the lysine linkage does not occur. Thus, if there is a mechanism by which glyphosate interferes with crosslink formation, this would explain its ability to enhance gluten sensitivity.

A clue can be found from the research literature on glyphosate sensitivity in plants, where it has been determined that the substitution of a lysine residue in a critical locale in EPSP synthase greatly increases sensitivity to glyphosate (Selvapandiyan *et al.*, 1995). Lysine's NH3+ group is highly reactive with negatively charged ions, and this makes it a common constituent of DNA binding proteins due to its ability to bind to phosphates in the DNA backbone. Glyphosate contains a phosphonyl group that binds easily to ammonia and behaves as a phosphate mimetic. It also contains a carboxyl group that substitutes well for the carboxyl group of glutamate, the intended reaction partner.

Thus, it seems possible that glyphosate would be drawn to the ammonia released when the glutamine residue is deamidated by transglutaminase, and then the ammonium glyphosate would react with the lysine residue, releasing the ammonia and resulting in the binding of glyphosate to the lysine residue. This would yield a gluten fragment bound to glyphosate that is likely highly allergenic. An analogous EPSP synthase-EPSP-glyphosate ternary complex has been identified in numerous studies on the physiology of glyphosate in plants (Sammons *et al.*, 1995).

Research in the food industry has concerned producing breads that, while not gluten free, may contain forms of gluten to which celiac patients are less sensitive. Such research has revealed that enzymatic modification to promote methionine binding to glutamine reduces IgA immunoreactivity (Cabrera-Chávez *et al.*, 2010). Whether methionine binding to glutamine residues in wheat takes place in vivo is not known, but it is established that glyphosate depletes methionine by 50 to 65 percent in plants, as well as the aromatic amino acids (Nafziger *et al.*, 1984; Haderlie *et al.*, 1977). As we have already discussed, glyphosate interferes with cobalt bioavailability for cobalamin synthesis, and cobalamin is an essential catalyst for the conversion of cysteine to methionine.

Transglutaminase also cross-links proteins in the extracellular matrix, and therefore is important for wound healing, tissue remodeling, and stabilization of the extracellular matrix. Thus, autoimmunity to transglutaminase leads to destabilization of the microvilli lining the small intestines. Transglutaminase has 18 free cysteine residues which are targets for S-nitrosylation. A cysteine residue is also involved in the catalytic active site. A unique Ca^{2+} dependent mechanism regulates nitrosylation by NO, mediated by CysNO (S-nitrosocysteine). It was shown experimentally that up to 15 cysteines of transglutaminase were nitrosylated by CysNO in the presence of Ca^{2+}, and this inhibited its enzymatic activity (Lai *et al.*, 2001).

Thus, another plausible mechanism by which glyphosate might enhance the development of autoantibodies to transglutaminase is by nitrosylating its cysteines, acting similarly to CysNO. A precedent for this idea is set with research proposing nitrosylation as the means by which glyphosate interferes with the heme active site in CYP enzymes (Lamb *et al.*, 1998). It is conceivable that cysteine nitrosylation by glyphosate at the active site inactivates the molecule, in which case glyphosate is itself acting as an "antibody."

13 Evidence of glyphosate exposure in humans and animals

The US EPA has accepted Monsanto's claim that glyphosate is essentially harmless to humans. Due to this position, there have been virtually no studies undertaken in the US to assess glyphosate levels in human blood or urine. However, a recent study involving multiple countries in Europe provides disturbing confirmation that glyphosate residues are prevalent in the Western diet (Hoppe, 2013). This study involved exclusively city dwellers, who are unlikely to be exposed to glyphosate except through food sources. Despite Europe's more aggressive campaign against GMO foods than that in the Americas, 44% of the urine samples contained quantifiable amounts of glyphosate. Diet seems to be the main source of exposure. One can predict that, if a study were undertaken in the U.S., the percentage of the affected population would be much larger.

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A recent study conducted on dairy cows in Denmark shows conclusively that the cows' health is being adversely affected by glyphosate (Krüger *et al.*, 2013a). All of the cows had detectable levels of glyphosate in their urine, and it was estimated that from 0.1 to 0.3 mg of glyphosate was excreted daily from each cow. More importantly, all of the cows had serum levels of cobalt and manganese that were far below the minimum reference level for nutrient sufficiency. Half of the cows had high serum urea, and there was a positive linear relationship between serum urea and glyphosate excretion. High serum urea is indicative of nephrotoxicity. Blood serum levels of enzymes indicative of cytotoxicity such as creatine kinase (CK) and alkaline phosphatase (ALP) were also elevated. CK is indicative of rhabdomyolysis or kidney failure. High levels of ALP indicate liver damage, and it is often used to detect blocked bile ducts (Kaplan *et al.*, 1983).

Thus, the low cobalt levels and the indicators of liver, kidney, and gall bladder stress are all consistent with our previous discussion. The results of this study were also consistent with results of a study on rats exposed experimentally to glyphosate (Beuret *et al.*, 2005) in which Roundup was shown to be even more toxic than its active ingredient, glyphosate.

Glyphosate-metal complexes serve to reduce glyphosate's toxicity in the soil to plants, but they also protect glyphosate from attack by microorganisms that could decompose it (Cusiel, 2005). The degree of reactivity of the complex depends on which metals glyphosate binds to, which in turn depends upon the particular soil conditions (Nomura & Hilton, 1977). Glyphosate usually degrades relatively quickly (Vencill, 2002); however, a half-life of up to 22 years has also been reported in conditions where pH is low and organic matter contents are high (Nomura & Hilton, 1977). Therefore, glyphosate may survive much longer in certain soils than has been claimed by the industry, and could be taken up by crops planted subsequent to glyphosate application to kill weeds.

A disturbing trend of crop desiccation by glyphosate pre-harvest (O'Keeffe, 1980; O'Keeffe, 1981; Stride *et al.*, 1985; Darwent *et al.*, 1994; Orson & Davies, 2007) may be a key factor in the increased incidence of celiac disease. According to Monsanto, glyphosate was used on some 13% of the wheat area pre-harvest in the UK in 2004. However, by 2006 and 2007, some 94% of UK growers used glyphosate on at least 40% of cereal and 80% of oilseed crops for weed control or harvest management (Monsanto International Sàrl, 2010).

An increasing number of farmers now consider the benefits of desiccating their wheat and sugar cane crops with glyphosate shortly before the harvest (Monsanto International Sàrl, 2010). The advantage is improved harvesting efficiency because the quantity of materials other than grain or cane is reduced by 17%, due to a shutdown of growth following glyphosate treatment. Treated sugar cane crops produce drier stalks which can be baled more easily. There is a shorter delay before the next season's crop can be planted, because the herbicide was applied pre-harvest rather than post-harvest. Several pests can be controlled due to the fact that glyphosate is a broad-spectrum herbicide. These include Black grass, Brome grasses, and Rye grasses, and the suggestion is that this would minimize the risk of these weeds developing resistance to other herbicides.

A complete list of the latest EPA residue levels for glyphosate as of September 18, 2013 are shown in Table 1. Tolerances are established on all crops for both human and animal consumption resulting from the application of glyphosate.

As glyphosate usage continues unabated, glyphosate resistance among weeds is becoming a growing problem (Waltz, 2010), necessitating a strategy that either involves an increase in the amount of glyphosate that is applied or a supplementation with other herbicides such as glufosinate, dicampa, 2-4D, or atrazine. Agrochemical companies are now actively developing crops with resistance to multiple herbicides (Culpepper, 2000), a disturbing trend, especially since glyphosate's disruption of CYP enzymes leads to an impaired ability to break down many other environmental chemicals in the liver.

14 Kidney disease in agricultural workers

Chronic kidney disease is a globally increasing problem (Ramirez-Rubio *et al.*, 2013), and glyphosate may be playing a role in this epidemic. A plot showing recent trends in hospitalization for acute kidney injury aligned with glyphosate usage rates on corn and soy shows strong correlation, as illustrated in Figure 4, and a similar correlation is seen for deaths due to end-stage renal disease in Figure 5. Recently, it has been noted that young men in Central America are succumbing in increasing numbers to chronic kidney disease (Trabanino *et al.*, 2002; Cerdas, 2005; Torres *et al.*, 2010; Peraza *et al.*, 2012; Ramirez-Rubio *et al.*, 2013; Sanoff *et al.*, 2010). The problem appears to be especially acute among agricultural workers, mainly in sugar cane fields (Cerdas, 2005; Torres *et al.*, 2010; Peraza *et al.*, 2012). Since we have shown in Section 8 how glyphosate can produce toxic effects on the kidneys through its disruption of gut bacteria, it is fruitful to consider whether glyphosate could be playing a role in the fate of Central American workers in the sugar cane fields.

In attempting to explain this phenomenon, physicians and pharmacists have proposed that it may be due to dehydration caused by over-exertion in high temperature conditions, combined with an acute reaction to commonly administered non-steroidal anti-inflammatory drugs (NSAIDs) to treat pain and/or antibiotics to treat infection (Ramirez-Rubio *et al.*, 2013). NSAIDs require CYP enzymes in the liver for detoxification (Agúndez *et al.*, 2009), so impaired CYP function by glyphosate would lead to a far more toxic effect of excessive NSAID administration. Kidney disease among agricultural workers tends to be associated with chronic glomerulonephritis and interstial nephritis, which was proposed in (Soderland *et al.*, 2010) to be

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Interdisciplinary Toxicology. 2013; **Vol. 6**(4): 159–184
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Table 1. Complete list of glyphosate tolerances for residues in food crops in the U.S. as of September 18, 2013, as reported in: EPA: Title 40: Protection of Environment.

Commodity	PPM
Acerola	0.2
Alfalfa, seed	0.5
Almond, hulls	25
Aloe vera	0.5
Ambarella	0.2
Animal feed, nongrass, group 18	400
Artichoke, globe	0.2
Asparagus	0.5
Atemoya	0.2
Avocado	0.2
Bamboo, shoots	0.2
Banana	0.2
Barley, bran	30
Beet, sugar, dried pulp	25
Beet, sugar, roots	10
Beet, sugar, tops	10
Berry and small fruit, group 13-07	0.20
Betelnut	1.0
Biriba	0.2
Blimbe	0.2
Breadfruit	0.2
Cacao bean, bean	0.2
Cactus, fruit	0.5
Cactus, pads	0.5
Canistel	0.2
Canola. seed	20
Carrot	5.0
Chaya	1.0
Cherimoya	0.2
Citrus, dried pulp	1.0
Coconut	0.1
Coffee, bean, green	1.0
Corn, pop, grain	0.1
Corn, sweet, kernel plus cob with husk removed	3.5
Cotton, gin byproducts	210
Custard apple	0.2
Dried fruit	0.2
Dokudami	2.0
Durian	0.2
Epazote	1.3
Feijoa	0.2
Fig	0.2
Fish	0.25
Fruit, citrus, group 10-10	0.50
Fruit, pome, group 11-10	0.20
Fruit, stone, group 12	0.2
Galangal, roots	0.2
Ginger, white, flower	0.2
Gourd, buffalo, seed	0.1
Governor's plum	0.2
Gow kee, leaves	0.2
Grain, cereal, forage, fodder and straw, group 16, except field corn, forage and field corn, stover	100
Grain, cereal, group 15 except field corn, popcorn, rice, sweet corn, and wild rice	30
Grass, forage, fodder and hay, group 17	300
Guava	0.2
Herbs subgroup 19A	0.2
Hop, dried cones	7.0
Ilama	0.2
Imbe	0.2
Imbu	0.2
Jaboticaba	0.2
Jackfruit	0.2
Kava, roots	0.2
Kenaf, forage	200
Leucaena, forage	200
Longan	0.2
Lychee	0.2
Mamey apple	0.2
Mango	0.2
Mangosteen	0.2
Marmalade box	0.2
Mioga, flower	0.2
Noni	0.20
Nut, pine	1.0
Nut, tree, group 14	1.0
Oilseeds, group 20, except canola	40
Okra	0.5
Olive	0.2
Oregano, Mexican, leaves	2,0
Palm heart	0.2
Palm heart, leaves	0.2
Palm, oil	0.1
Papaya	0.2
Papaya, mountain	0.2
Passionfruit	0.2
Pawpaw	0.2
Pea, dry	8.0
Peanut	0.1
Peanut, hay	0.5
Pepper leaf, fresh leaves	0.2
Peppermint, tops	200
Perilla, tops	1.8
Persimmon	0.2
Pineapple	0.1
Pistachio	1.0
Pomegranate	0.2
Pulasan	0.2
Quinoa. grain	5.0
Rambutan	0.2
Rice, grain	0.1
Rice, wild, grain	0.1
Rose apple	0.2
S apod ilia	0.2
Sapote, black	0.2
Sapote, mamey	0.2
Sapote, white	0.2
Shellfish	3.0
Soursop	0.2
Spanish lime	0.2
Spearmint, tops	200
Spice subgroup 19B	7.0
Star apple	0.2
Starfruit	0.2
Stevia, dried leaves	1.0
Sugar apple	0.2
Sugarcane, cane	2.0
Sugarcane, molasses	30
Surinam cherry	0.2
Sweet potato	3.0
Tamarind	0.2
Tea. dried	1.0
Tea, instant	7.0
Teff, forage	100
TefF, grain	5.0
Teff, hay	100
Ti, leaves	0.2
Ti, roots	0.2
Ugli fruit	0.5
Vegetable, bulb, group 3-07	0.20
Vegetable, cucurbit, group 9	0.5
Vegetable, foliage of legume, subgroup 7A, except soybean	0.2
Vegetable, fruiting, group 8-10 (except okra)	0.10
Vegetable, leafy, brassica. group 5	0.2
Vegetable, leafy, except brassica, group 4	0.2
Vegetable, leaves of root and tuber, group 2, except sugar beet tops	0.2
Vegetable, legume, group 6 except soybean and dry pea	5.0
Vegetables, root and tuber, group 1, except carrot, sweet potato, and sugar beet	0.20
Wasabi. roots	0.2
Water spinach, tops	0.2
Watercress, upland	0.2
Wax jambu	0.2

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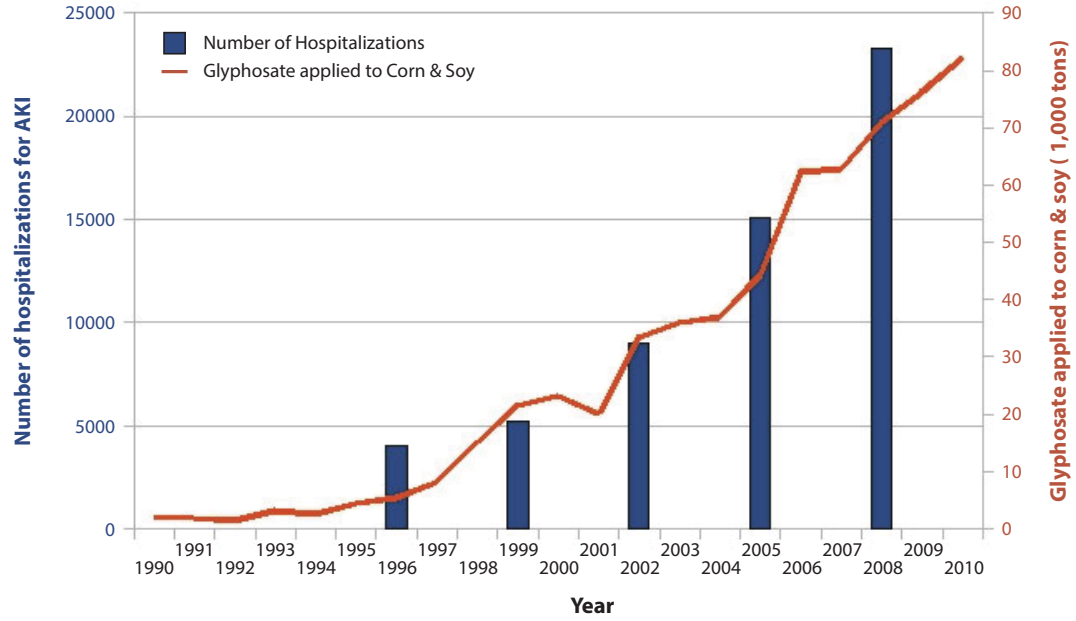

Figure 4. Number of hospitalizations for acute kidney injury plotted against glyphosate applied to com & soy (in 1000 tons). (Figure courtesy of Nancy Swanson).

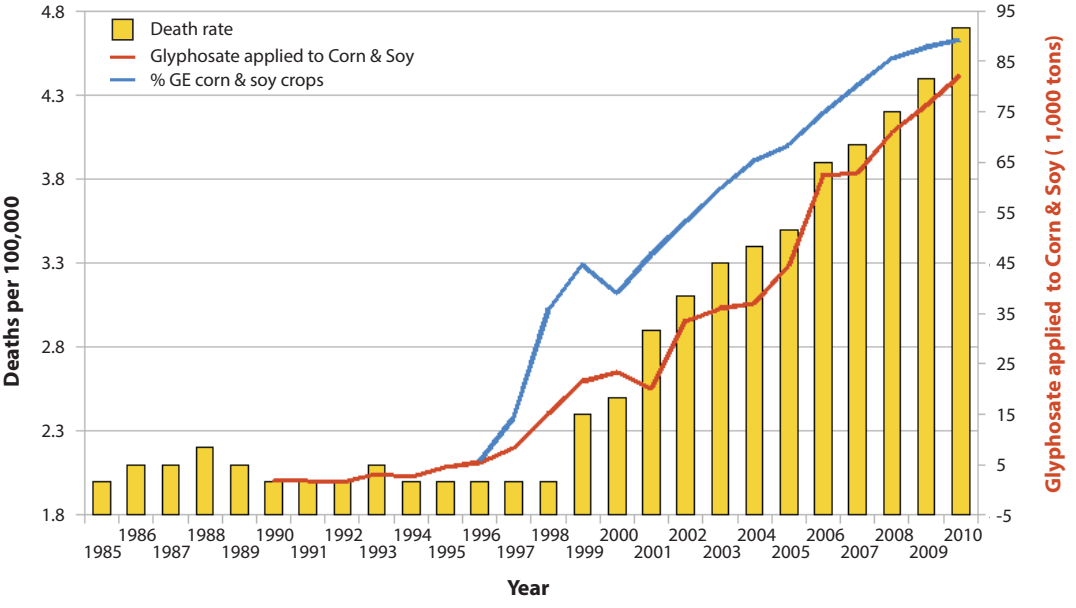

Figure 5. End stage renal disease deaths (ICD N18.0 & 585.6) plotted against %GE corn & soy planted (R=0.9585, p<4.03e-6) and glyphosate applied to corn & soy (R=0.9844, $p \leq 3.704e-09$). Sources: USDA:NASS; CDC. (Figure courtesy of Nancy Swanson).

due to environmental toxins such as heavy metals or toxic chemicals. Glomerulonephritis is also found in association with celiac disease (Katz *et al.*, 1979; Peters *et al.*, 2003). A Swedish study showed a five-fold increase in nephritis risk in celiac patients (Peters *et al.*, 2003).

A strong hint comes from epidemiological studies conducted in Costa Rica (Cerdas, 2005). The demographic features of those with chronic renal failure revealed a remarkably specific pattern of young men, between 20 and 40 years old, with chronic interstitial nephritis. All

ISSN: 1337-6853 *(print version)* | 1337-9569 *(electronic version)*

Interdisciplinary Toxicology. 2013; **Vol. 6**(4): 159–184
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of them were sugar-cane workers. These authors wrote: "A specific study of their work environment is needed to determine what in their daily activities puts them at increased risk for chronic renal failure."

Agriculture is an important part of the economy of the state of Louisiana in the United States, and sugar cane is a significant agricultural product. Chemical methods to ripen sugar cane are commonly used, because they can substantially increase the sucrose content of the harvest (Richard & Dalley, 2009). Glyphosate, in particular, has been the primary ripener used in Louisiana since 1980 (Orgeron, 2012). As of 2001, Louisiana had the highest rate of kidney failure in the U.S. (State-Specific Trends in Chronic Kidney Failure – United States, 1990–2001). Louisiana's death rate per 100,000 from nephritis/kidney disease is 26.34 as compared to a U.S. rate of 14.55 (Network Coordinating Council, 2013). The number of patients on dialysis has risen sharply in the last few years.

By 2005, it is estimated that 62% of the total harvested hectares of sugar cane in Louisiana were ripened with glyphosate (Legendre *et al.*, 2005). A paper published in 1990 showed that glyphosate applied as a ripener on three different sugar cane varieties grown *in Costa Rica* produced up to a 15% increase in the sucrose content of the harvested sugar cane (Subiros, 1990). Glyphosate applied before the harvest is the *only* sugarcane ripener currently registered for use in the U.S.

A disturbing recent trend is the repeated application of glyphosate over the course of the season with the hope of further increasing yields (Richard & Dalley, 2009). Responses to the standard application rate (0.188 lb/acre) of glyphosate have been inconsistent, and so farmers are increasing both the amount and the frequency of application. In (Richard & Dalley, 2009), growers are encouraged not to apply glyphosate beyond mid-October, as results are counterproductive, and not to use higher rates in an attempt to improve yield. But it is doubtful that these recommendations are being followed. It is likely, although we have not been able to confirm this, that glyphosate usage has expanded in scope on the sugar cane fields in Central America since 2000, when the expiration of Monsanto's patent drove prices down, and that the practices of multiple applications of glyphosate in the U.S. are also being followed in Central America. Several other ripening agents exist, such as Ethephon, Trinexapacethyl, and Sulfometuron-methyl, but glyphosate is likely growing in popularity recently due to its more favorable pricing and perceived non-toxicity. Larger amounts are needed for effective ripening in regions that are hot and rainy, which matches the climate of Costa Rica and Nicaragua.

15 Discussion

In this paper, we have developed an argument that the alarming rise in the incidence of celiac disease in the United States and elsewhere in recent years is due to an increased burden of herbicides, particularly glyphosate exposure in the diet. We suggest that a principal factor is the use of glyphosate to desiccate wheat and other crops prior to the harvest, resulting in crop residue and increased exposure. Strong evidence for a link between glyphosate and celiac disease comes from a study on predatory fish, which showed remarkable effects in the gut that parallel the features of celiac disease (Shenapati *et al.*, 2009).

More generally, inflammatory bowel disease has been linked to several environmental factors, including a higher socioeconomic status, urban as opposed to rural dwelling, and a "Westernized" cultural context (Shapira *et al.*, 2010). Disease incidence is highest in North America and Europe, and is higher in northern latitudes than in southern latitudes within these regions, suggesting a beneficial role for sunlight. According to the most recent statistics from the U.S. Environmental Protection Agency (EPA) (Grube *et al.*, 2011), the U.S. currently represents 25% of the total world market on herbicide usage. Glyphosate has been the most popular herbicide in the U.S. since 2001, whereas it was the 17th most popular herbicide in 1987 (Kiely *et al.*, 2004). Since 2001, glyphosate usage has grown considerably, due to increased dosing of glyphosate-resistant weeds and in conjunction with the widespread adoption of "Roundup-Ready" genetically modified crops. Glyphosate is probably now the most popular herbicide in Europe as well (Kimmel *et al.*, 2013). Glyphosate has become the number one herbicide worldwide, due to its perceived lack of toxicity and its lower price after having become generic in 2000 (Duke & Powles, 2008).

A recent estimate suggests that one in twenty people in North America and Western Europe suffer from celiac disease (Koning, 2005; Fasano *et al.*, 2003). Outdoor occupational status is protective (Sonnenberg *et al.*, 1991). First generation immigrants into Europe or North America are generally less susceptible, although second generation non-Caucasian immigrants statistically become even more susceptible than native Caucasians (Shapira *et al.*, 2010). This may in part stem from the increased need for sunlight exposure given darker skin pigmentation.

Table 2 summarizes our findings relating glyphosate to celiac disease. All of the known biological effects of glyphosate – cytochrome P450 inhibition, disruption of synthesis of aromatic amino acids, chelation of transition metals, and antibacterial action – contribute to the pathology of celiac disease.

Celiac disease is associated with deficiencies in several essential micronutrients such as vitamin D3, cobalamin, iron, molybdenum, selenium and the amino acids, methionine and tryptophan, all of which can be explained by glyphosate. Glyphosate depletes multiple minerals in both genetically modified soybeans (Saes *et al.*, 2010) and conventional soybeans (Cakmak *et al.*, 2009), which would translate into nutritional deficiencies in foods derived from these crops. This, together with further chelation in the gut by any direct glyphosate exposure, could explain deficiencies in cobalt, molybdenum and iron. Glyphosate's effect on CYP enzymes should lead to inadequate vitamin D3 activation in the liver (Hietanen *et al.*, 1983; Ponchon *et al.*, 1969). Cobalamin depends

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Table 2. Illustration of the myriad ways in which glyphosate can be linked to celiac disease or its associated pathologies.

(a) Disruption of gut bacteria

Glyphosate Effect	Dysfunction	Consequences
reduced Bifidobacteria	impaired gluten breakdown	transglutaminase antibodies
reduced Lactobacillus	impaired phytase breakdown reduced selenoproteins	metal chelation autoimmune thyroid disease
anaerobic E. coli	indole toxicity	kidney failure
C. diff overgrowth	p-Cresol toxicity	kidney failure
Desulfovibrio overgrowth	hydrogen sulfide gas	inflammation

(b) Transition metal chelation

Glyphosate Effect	Dysfunction	Consequences
cobalt deficiency	cobalamin deficiency reduced methionine elevated homocysteine	neurodegenerative diseases impaired protein synthesis heart disease
molybdenum deficiency	inhibited sulfite oxidase inhibited xanthine oxidase	impaired sulfate supply DNA damage/cancer teratogenesis megaloblastic anemia
iron deficiency		anemia

(c) CYP enzyme inhibition

Glyphosate Impairment	Dysfunction	Consequences
vitamin D3 inactivation	impaired calcium metabolism	osteoporosis; cancer risk
retinoic acid catabolism	suppressed transglutaminase	teratogenesis
bile acid synthesis	impaired fat metabolism impaired sulfate supply	gall bladder disease pancreatitis
xenobiotic detoxification	increased toxin sensitivity impaired indole breakdown	liver disease macrocytic anemia kidney failure
nitrate reductase	venous constriction	venous thrombosis

(d) Shikimate pathway suppression

Glyphosate Effect	Dysfunction	Consequences
tryptophan deficiency	impaired serotonin supply hypersensitive receptors	depression nausea, diarrhea

on cobalt, and cobalt-dependent enzymes in plants and microbes have been shown to be inhibited by glyphosate (Bode *et al.*, 1984; Ganson and Jensen, 1988). Glyphosate has been shown to severely impair methionine and tryptophan synthesis in plants (Nafziger *et al.*, 1984), which would reduce the bioavailability of these nutrients in derived foods.

There are multiple intriguing connections between celiac disease and microcephaly, all of which can be linked to glyphosate. Celiac disease is found in association with microcephaly in infants (Bostwick *et al.*, 2001; Lapunzina, 2002), and teratogenic effects are also observed in children born to celiac mothers (Dickey *et al.*, 1996; Martinelli *et al.*, 2000). Microcephaly in an infant where confirmed molybdenum deficiency was present (Boles *et al.*, 1993) suggests that molybdenum deficiency could be causal. However, elevated RA also induces microcephaly, as does indole-3-acetic acid, which has been dramatically linked to microcephaly in mice (Furukawa *et al.*, 2007). Elevated RA is predicted as a response to glyphosate due to its expected inhibition of CYP enzymes which catabolize RA in the liver (Lamb *et al.*, 1998; Hietanen *et al.*, 1983). Molybdenum deficiency is expected due to glyphosate's ability to chelate cationic minerals. Glyphosate has been shown to induce indole-3-acetic acid synthesis in plants (Caal *et al.*, 1987), and it induces a shift to anaerobic metabolism in E. coli (Lu *et al.*, 2013), which is associated with indole synthesis.

Celiac disease is associated with impaired serotonin metabolism and signaling in the gut, and this feature leads us to propose a novel role for serotonin in transporting sulfate to the tissues. It is a curious and little known fact that glucose and galactose, but not fructose or mannose, stimulate 5-HT synthesis by EC cells in the intestinal

ISSN: 1337-6853 *(print version)* | 1337-9569 *(electronic version)*

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Interdisciplinary Toxicology. 2013; **Vol. 6**(4): 159–184
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lumen (Kim *et al.*, 2001), suggesting a role for EC cells as "glucose sensors." Glucose and galactose are the two sugars that make up the heparan sulfate chains of the syndecans and glypicans that attach to the membrane-bound proteins in most cells, serving as the innermost constituency of the extracellular matrix (Bernfield *et al.*, 1999). In (Seneff *et al.*, 2012), it was proposed that part of the post-prandial glucose that is taken up by the tissues is temporarily stored in the extracellular matrix as heparan sulfate, and that a deficiency in sulfate supply impairs this process, which impedes glucose uptake in cells. These heparan sulfate units have a high turnover rate, as they are typically broken down within three hours of their initial placement (Turnbull *et al.*, 2001). This provides the cells with a convenient temporary buffer for glucose and galactose that can allow them to more efficiently remove these sugars from the serum. Insufficient sulfate supplies would impair this process and lead to insulin resistance.

As is the case for other monoamine neurotransmitters as well as most sterols, 5-HT is normally transported in the serum in a sulfated form. The sulfate moiety must be removed for the molecule to activate it. Therefore, 5-HT, as well as these other monoamine neurotransmitters and sterols, can be viewed as a sulfate "escort" in the plasma. In (Samsel & Seneff, 2013), it was argued that such carbon-ring-containing molecules are necessary for safe sulfate transport, especially in the face of co-present kosmotropes like glyphosate, in order to protect the blood from excess viscosity during transport. Support for the concept that glyphosate gels the blood comes from the observation that disseminated coagulation is a characteristic feature of glyphosate poisoning (Zouaoui *et al.*, 2013). Since glyphosate disrupts sterol sulfation and it disrupts monoamine neurotransmitter synthesis, in addition to its physical kosmotropic feature, it can be anticipated that a chronic exposure to even a small amount of glyphosate over the course of time will lead to a system-wide deficiency in the supply of sulfate to the tissues. We believe that this is the most important consequence of glyphosate's insidious slow erosion of health.

An interesting consideration regarding a known link between celiac disease and hypothyroidism (Collins *et al.*, 2012) emerges when one considers that iodide is one of the few chaotropic (structure breaking) anions available to biological systems: another important one being nitrate, which is elevated in the urine in association with celiac disease (Laurin *et al.*, 2003). It is intriguing that the conversion of T4 to T3 (the active form of thyroid hormone) involves selenium as an essential cofactor. Furthermore, iodide is released in the process, thus providing chaotropic buffering in the blood serum. Therefore, impaired conversion due to deficient selenium results in an inability to buffer this significant chaotrope in the blood, despite the fact that chaotropic buffering is likely desperately needed in the context of the kosmotropic effects of glyphosate. While speculative, it is possible that the autoimmune thyroid disease that develops in association with celiac disease is a direct consequence of the inability to activate thyroid hormone due to insufficient selenium. Indeed, celiac patients with concurrent hypothyroidism require an elevated dose of levothyroxine (T4) compared to non-celiac hypothyroid patients (Collins *et al.*, 2012), which could be due to impaired activation to T3.

The link between autoimmune (type 1) diabetes and autoimmune thyroiditis is likely tied to deficiencies in selenoproteins leading to apoptosis. Diabetic rats produce significantly less glomerular heparan sulfate in the kidneys than controls, and this is associated with increased albuminurea (Jaya *et al.*, 1993). However, children with type-1 diabetes and celiac disease excrete lower levels of albumin than type-1 diabetic children without celiac disease, suggesting a protective role for celiac disease (Gopee *et al.*, 2013). Wheat is a good source of tryptophan, so it is likely that tryptophan-derived serotonin induces the symptoms of diarrhea and nausea associated with wheat ingestion, but, at the same time, transports available sulfate through the vasculature, to help maintain adequate supplies of heparan sulfate to the glomerulus. Thus, the increased metabolism of dietary tryptophan to serotonin observed in association with celiac disease may help ameliorate the sulfate deficiency problem. Glyphosate's interference with CYP enzymes links to impaired bile-acid production in the liver, which in turn impairs *sterol*-based sulfate transport, placing a higher burden on serotonin for this task.

We have argued here that kidney failure, a known risk factor in celiac disease, is a consequence of depleted sulfate supplies to the kidneys. An alarming increase in kidney failure in young male agricultural workers in sugar cane fields in South America can be directly linked to the recent increase in the practice of using Roundup to "ripen" the crop just prior to the harvest. Furthermore, glyphosate's interference with selenoprotein supply would lead to thyroid dysfunction, which greatly increases risk to kidney disease. We propose here that glyphosate is the key environmental factor contributing to this epidemic, but further investigation is warranted.

While we have covered a broad range of pathologies related to celiac disease in this paper, and have shown how they can be explained by glyphosate exposure, there are likely still other aspects of the disease and the connection to glyphosate that we have omitted. For example, in a remarkable case study (Barbosa, 2001), a 54-year-old man who accidentally sprayed himself with glyphosate developed skin lesions six hours later. More significantly, one month later he exhibited symptoms of Parkinson's disease. Movement disorders such as Parkinsonism are associated with gluten intolerance (Baizabal-Carvallo, 2012). Figure 6 shows plots of glyphosate application to corn and soy alongside plots of deaths due to Parkinson's disease. These and other connections will be further explored in future research.

16 Conclusion

Celiac disease is a complex and multifactorial condition associated with gluten intolerance and a higher risk to thyroid disease, cancer and kidney disease, and there is also

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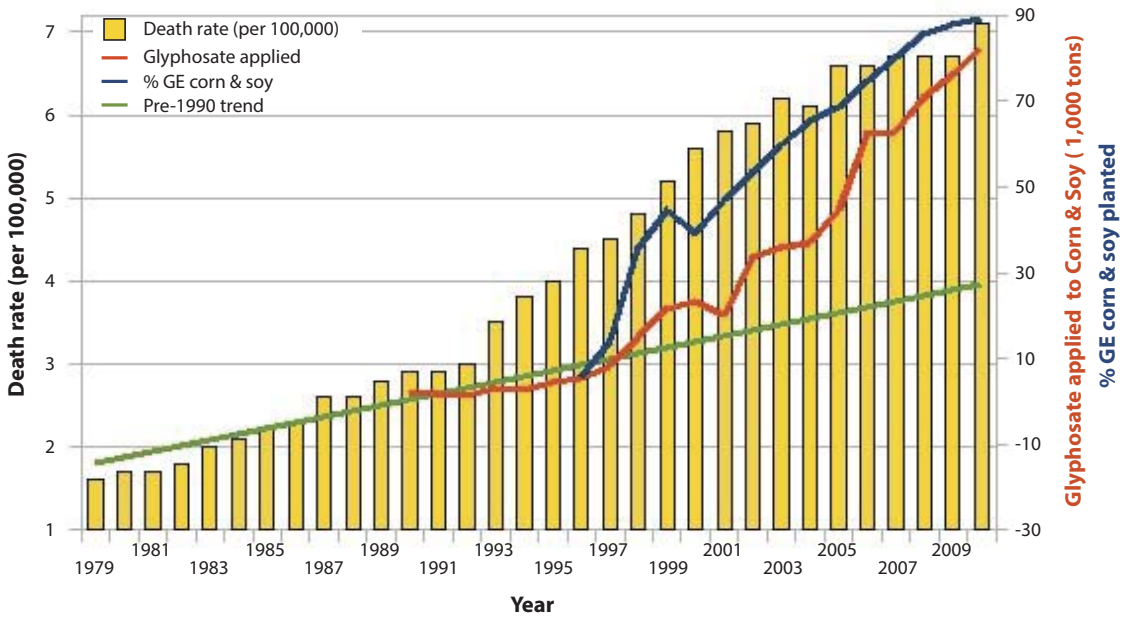

Figure 6. Deaths from Parkinson's disease (ICD G20 & 332.0) plotted against glyphosate use on corn & soy (R=0.9006, $p \leq 5.063e\text{-}07$) and %GE corn & soy planted (R=0.9676, $p \leq 2.714e\text{-}06$). Sources: USDA:NASS; CDC. (Figure courtesy of Nancy Swanson).

an increased risk to infertility and birth defects in children born to celiac mothers. While the principal diagnostic is autoantibodies to tissue transglutaminase, celiac disease is associated with a spectrum of other pathologies such as deficiencies in iron, vitamin D3, molybdenum, selenium, and cobalamin, an overgrowth of pathogens in the gut at the expense of beneficial biota, impaired serotonin signaling, and increased synthesis of toxic metabolites like p-Cresol and indole-3-acetic acid. In this paper, we have systematically shown how all of these features of celiac disease can be explained by glyphosate's known properties. These include (1) disrupting the shikimate pathway, (2) altering the balance between pathogens and beneficial biota in the gut, (3) chelating transition metals, as well as sulfur and selenium, and (4) inhibiting cytochrome P450 enzymes. We argue that a key system-wide pathology in celiac disease is impaired sulfate supply to the tissues, and that this is also a key component of glyphosate's toxicity to humans.

The monitoring of glyphosate levels in food and in human urine and blood has been inadequate. The common practice of desiccation and/or ripening with glyphosate right before the harvest ensures that glyphosate residues are present in our food supply. It is plausible that the recent sharp increase of kidney failure in agricultural workers is tied to glyphosate exposure. We urge governments globally to reexamine their policy towards glyphosate and to introduce new legislation that would restrict its usage.

Acknowledgements

The authors would like to thank Nancy Swanson for her gracious effort in the creation of the informative pictorial graphs included with the text. Her statistical research for glyphosate usage and disease over time is an invaluable contribution to our paper. Stephanie Seneff would also like to personally thank Jennifer Moeny for her most informative discussions concerning current associative prognosis, research and trends in Celiac disease and gluten intolerance. This work was funded in part by Quanta Computers, Taipei, Taiwan, under the auspices of the Qmulus Project.

Disclosures: *The authors have nothing to disclose.*

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ISSN: 1337-6853 *(print version)* | 1337-9569 *(electronic version)*

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ISSN: 1337-6853 *(print version)* | 1337-9569 *(electronic version)*

Surgical Neurology International

OPEN ACCESS

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Editor:
James I. Ausman, MD, PhD
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Original Article

Glyphosate, pathways to modern diseases III: Manganese, neurological diseases, and associated pathologies

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Received: 22 September 14 Accepted: 21 January 15 Published: 24 March 15

This article may be cited as:
Samsel A, Seneff S. Glyphosate, pathways to modern diseases III: Manganese, neurological diseases, and associated pathologies. Surg Neurol Int 2015;6:45.
Available FREE in open access from: http://www.surgicalneurologyint.com/text.asp?2015/6/1/45/153876

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Abstract

Manganese (Mn) is an often overlooked but important nutrient, required in small amounts for multiple essential functions in the body. A recent study on cows fed genetically modified Roundup®-Ready feed revealed a severe depletion of serum Mn. Glyphosate, the active ingredient in Roundup®, has also been shown to severely deplete Mn levels in plants. Here, we investigate the impact of Mn on physiology, and its association with gut dysbiosis as well as neuropathologies such as autism, Alzheimer's disease (AD), depression, anxiety syndrome, Parkinson's disease (PD), and prion diseases. Glutamate overexpression in the brain in association with autism, AD, and other neurological diseases can be explained by Mn deficiency. Mn superoxide dismutase protects mitochondria from oxidative damage, and mitochondrial dysfunction is a key feature of autism and Alzheimer's. Chondroitin sulfate synthesis depends on Mn, and its deficiency leads to osteoporosis and osteomalacia. Lactobacillus, depleted in autism, depend critically on Mn for antioxidant protection. Lactobacillus probiotics can treat anxiety, which is a comorbidity of autism and chronic fatigue syndrome. Reduced gut Lactobacillus leads to overgrowth of the pathogen, Salmonella, which is resistant to glyphosate toxicity, and Mn plays a role here as well. Sperm motility depends on Mn, and this may partially explain increased rates of infertility and birth defects. We further reason that, under conditions of adequate Mn in the diet, glyphosate, through its disruption of bile acid homeostasis, ironically promotes toxic accumulation of Mn in the brainstem, leading to conditions such as PD and prion diseases.

Key Words: Autism, cholestasis, glyphosate, manganese, Parkinson's disease

Access this article online

Website: www.surgicalneurologyint.com

DOI: 10.4103/2152-7806.153876

Quick Response Code:

INTRODUCTION

Glyphosate is the active ingredient in Roundup®, the most widely used herbicide on the planet.[314] Glyphosate enjoys widespread usage on core food crops, in large part because of its perceived nontoxicity to humans. The adoption of genetically engineered "Roundup®-Ready" corn, soy, canola, cotton, alfalfa, and sugar beets has made it relatively easy to control weeds without killing the crop plant, but this means that glyphosate will be present as a residue in derived foods. Unfortunately, weeds among GM Roundup®-Ready crops are developing ever-increasing resistance to Roundup®,[107,221] which requires an increased rate of herbicide application.[26]

In 1987, glyphosate was the 17th most commonly used herbicide in the United States, but, in large part due to the introduction of glyphosate-resistant core crops, it became the number one herbicide by 2001.[146] Its usage has increased steadily since then, in step with the rise in autism rates. Glyphosate's perceived nontoxicity is predicated on the assumption that our cells do not possess the shikimate pathway, the biological pathway in plants, which is disrupted by glyphosate, and whose disruption is believed to be the most important factor in its toxicity.

It may seem implausible that glyphosate could be toxic to humans, given the fact that government regulators appear nonchalant about steadily increasing residue limits, and that the levels in food and water are rarely monitored by government agencies, presumably due to lack of concern. However, a paper by Antoniou *et al*.[12] provided a scathing indictment of the European regulatory process regarding glyphosate's toxicity, focusing on potential teratogenic effects. They identified several key factors leading to a tendency to overlook potential toxic effects. These include using animal studies that are too short or have too few animals to achieve statistical significance, disregarding *in vitro* studies or studies with exposures that are higher than what is expected to be realistically present in food, and discarding studies that examine the effects of glyphosate formulations rather than pure glyphosate, even though formulations are a more realistic model of the natural setting and are often orders of magnitude more toxic than the active ingredient in pesticides.[189] Regulators also seemed unaware that chemicals that act as endocrine disruptors (such as glyphosate[108]) often have an inverted dose–response relationship, wherein very low doses can have more acute effects than higher doses. Teratogenic effects have been demonstrated in human cell lines.[212] An *in vitro* study showed that glyphosate in parts per trillion can induce human breast cancer cell proliferation.[289]

Adjuvants in pesticides are synergistically toxic with the active ingredient. Mesnage *et al*.[189] showed that Roundup® was 125 times more toxic than glyphosate by itself. These authors wrote: "Despite its relatively benign reputation, Roundup® was among the most toxic herbicides and insecticides tested."[189]

The industry dictates that 3 months is a sufficiently long time to test for toxicity in rodent studies, and as a consequence none of the industry studies have run for longer than 3 months. The only study we are aware of that was a realistic assessment of the long-term effects of GM Roundup®-Ready corn and soy feed on mammals was the study by Séralini *et al*. that examined the effects on rats fed these foods for their entire life span.[261] This study showed increased risk to mammary tumors in females, as well as kidney and liver damage in the males, and a shortened lifespan in both females and males. These effects occurred both in response to Roundup and to the GM food alone. These effects only began to be apparent after 4 months.

There are multiple pathways by which glyphosate could lead to pathology.[248] A major consideration is that our gut bacteria *do* have the shikimate pathway, and that we depend upon this pathway in our gut bacteria as well as in plants to supply us with the essential aromatic amino acids, tryptophan, tyrosine, and phenylalanine. Methionine, an essential sulfur-containing amino acid, and glycine, are also negatively impacted by glyphosate. Furthermore, many other biologically active molecules, including serotonin, melatonin, melanin, epinephrine, dopamine, thyroid hormone, folate, coenzyme Q10, vitamin K, and vitamin E, depend on the shikimate pathway metabolites as precursors. Gut bacteria and plants use exclusively the shikimate pathway to produce these amino acids. In part because of shikimate pathway disruption, our gut bacteria are harmed by glyphosate, as evidenced by the fact that it has been patented as an antimicrobial agent.[298]

Metal chelation and inactivation of cytochrome P450 (CYP) enzymes (which contain heme) play important roles in the adverse effects of glyphosate on humans. A recent study on rats showed that both males and females exposed to Roundup® had 50% reduction in hepatic CYP enzyme levels compared with controls.[156] CYP enzyme dysfunction impairs the liver's ability to detoxify xenobiotics. A large number of chemicals have been identified as being porphyrinogenic.[77] Rossignol *et al*.[242] have reviewed the evidence for environmental toxicant exposure as a causative factor in autism, and they referenced several studies showing that urinary excretion of porphyrin precursors to heme is found in association with autism, suggesting impaired heme synthesis. Impaired biliary excretion leads to increased excretion of heme precursors in the urine, a biomarker of multiple chemical sensitivity syndrome.[77] We later discuss the ability of glyphosate to disrupt bile homeostasis, which we believe is a major source of its toxic effects on humans.

Glyphosate is a likely cause of the recent epidemic in celiac disease.[249] Glyphosate residues are found in wheat due to the increasingly widespread practice of staging and desiccation of wheat right before harvest. Many of the pathologies associated with celiac disease can be explained by disruption of CYP enzymes.[156] Celiac patients have a shortened life span, mainly due to an increased risk to cancer, most especially non-Hodgkin's lymphoma, which has also been linked to glyphosate.[85,253] Celiac disease trends over time match well with the increase in glyphosate usage on wheat crops.

Glyphosate is also neurotoxic.[59] Its mammalian metabolism yields two products: Aminomethylphosphonic acid (AMPA) and glyoxylate, with AMPA being at least as

toxic as glyphosate. Glyoxylate is a highly reactive glycating agent, which will disrupt the function of multiple proteins in cells that are exposed.[90] Glycation has been directly implicated in Parkinson's disease (PD).[57] Glyphosate has been detected in the brains of malformed piglets.[155] In a report produced by the Environmental Protection Agency (EPA), over 36% of 271 incidences involving acute glyphosate poisoning involved neurological symptoms, indicative of glyphosate toxicity in the brain and nervous system.[122]

In the remainder of this paper, we first introduce the link between glyphosate and manganese (Mn) dysbiosis, and briefly describe the main biological roles of Mn. We then describe how glyphosate's disruption of gut bacteria may be a major player in the recent epidemic in antibiotic resistance. We then explain how glyphosate can influence the uptake of arsenic and aluminum, and propose similar mechanisms at work with Mn. In the next section, we describe how Mn deficiency can lead to a reduction in Lactobacillus in the gut, and we link this to anxiety disorder. We follow with a discussion on mitochondrial dysfunction associated with suppressed Mn superoxide dismutase (Mn-SOD), and then a section on implications of Mn deficiency for oxalate metabolism. The following section explains how Mn deficiency can lead to the overexpression of ammonia and glutamate in many neurological diseases. The next two sections show how Mn accumulation in the liver is linked to cholestasis and high serum low density lipoprotein (LDL), and how this can also induce increased susceptibility to Salmonella poisoning. We then identify a role for Mn in chondroitin sulfate synthesis, and the implications for osteomalacia. The next two sections explain how glyphosate exposure can lead to Mn toxicity in the brain, and discuss two neurological diseases that are associated with excess Mn, PD and prion diseases. After a section on the link between male infertility and Mn deficiency in the testes, we discuss evidence of exposure to glyphosate and end with a short summary of our findings.

SUPPORTIVE EVIDENCE OF MANGANESE DYSBIOSIS DUE TO GLYPHOSATE

Glyphosate's disruption of the shikimate pathway is due in part to its chelation of Mn, which is a catalyst for enolpyruvylshikimate phosphate synthase (EPSPS), a critical early enzyme in the pathway.[63] A recent study on Danish dairy cattle investigated mineral composition in serum of cattle fed Roundup®-Ready feed.[154] The study identified a marked deficiency in two minerals: Serum cobalt and serum Mn. All of the cattle on eight different farms had severe Mn deficiency, along with measurable amounts of glyphosate in their urine. In Australia, following two seasons of high levels of stillbirths in cattle, it was found that all dead calves were Mn deficient.[184] Furthermore, 63% of newborns with birth defects were found to be deficient in Mn.

Mn, named after the Greek word for "magic," is one of 14 essential trace elements. Mn plays essential roles in antioxidant protection, glutamine synthesis, bone development, and sperm motility, among other things. Although Mn is essential, it is only required in trace amounts. And an excess of Mn can be neurotoxic.

Remarkably, Mn deficiency can explain many of the pathologies associated with autism and Alzheimer's disease (AD). The incidence of both of these conditions has been increasing at an alarming rate in the past two decades, in step with the increased usage of glyphosate on corn and soy crops in the United States, as shown in [Figures 1 and 2]. Although correlation does not necessarily mean causation, from 1995 to 2010, the autism rates in first grade in the public school correlates almost perfectly ($P = 0.997$) with total glyphosate application on corn and soy crops over the previous 4 years (from age 2 to 6 for each child) [Figure 1]. Such remarkable correlation necessitates further experimental investigation. These neurological disorders are associated with mitochondrial impairment[197,241,243,281,316] and with excess glutamate and ammonia in the brain,[2,109,265] leading to a chronic low-grade encephalopathy.[256,260] As we will show later, Mn deficiency is critically associated with these pathologies.

Thyroid dysfunction can be predicted as well, and low maternal thyroid function predicts autism in the fetus.[238] Furthermore, increases in bone fractures in both children and the elderly can also be explained by Mn deficiency, due to its critical role in bone development.[276] Osteoporosis, which is a serious problem

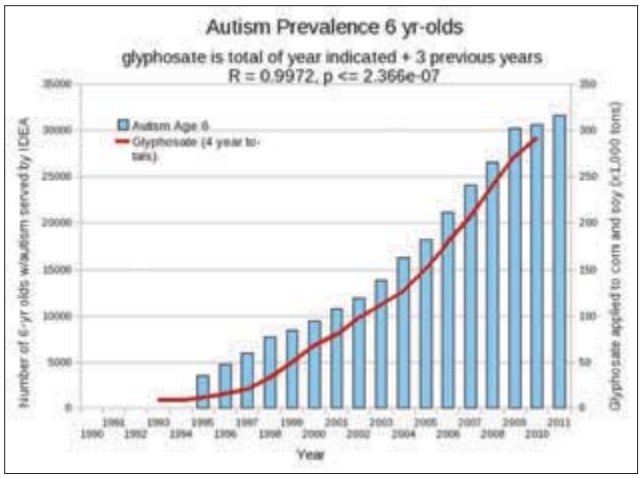

Figure 1: Plots of amount of glyphosate applied to corn and soy crops in the US over the previous 4 years (red), provided by the US Department of Agriculture, compared with number of children enrolled in the first grade in the public school system under the autism category according to the Individuals with Disabilities Education Act (IDEA) (blue bars). (Figure courtesy of Dr. Nancy Swanson)

among the elderly today, is also likely promoted by Mn deficiency,[247] and osteoporosis leads to increased risk to fractures.[98,139,140]

Sprague-Dawley rats fed a Mn-deficient diet had significantly reduced concentrations of Mn in liver, kidney, heart, and pancreas, compared with controls.[18] Furthermore, pancreatic insulin content was only 63% of control levels, and insulin release following glucose administration was also reduced. Mn deficiency not only impairs insulin secretion in Sprague-Dawley rats, but it also causes reduced glucose uptake in adipose tissue,[19] so Mn deficiency could contribute to impaired glucose metabolism in both type 1 and type 2 diabetes, which are a growing problem worldwide.[199] Type 1 diabetes in children is associated with a decrease in Lactobacillus and Bifidobacterium, and an increase in Clostridium, in the gut.[195] These same pathologies are also found in gut bacteria from poultry fed Roundup®-Ready feed.[263] The increased incidence of diabetes in the US is strongly correlated with glyphosate usage on corn and soy, as shown in [Figure 3].

Much remains elusive about Mn's roles in cellular metabolism, but it is clear that it is very important. For instance, Target of Rapamycin Complex 1 (TORC1) accelerates the aging process in cells from yeast to mammals,[231] and Mn inhibits TORC1, but only if it is present in the Golgi.[86] Zinc (Zn) is essential for DNA and RNA replication and cell division. Zn deficiency leads to greatly enhanced Mn uptake by cells, and this induces modifications to messenger RNA such that the ratio of guanine and cytosine nucleotides (C + G) to adenine and thymine (A + T) is sharply increased.[100] Clearly, more research is needed to explain the significance of these phenomena.

We infer, paradoxically, that both Mn deficiency and Mn toxicity, attributable to glyphosate, can occur simultaneously. Because of glyphosate's disruption of CYP enzymes, the liver becomes impaired in its ability to dispose of Mn via the bile acids, and instead it transports the Mn via the vagus nerve to brainstem nuclei, where excess Mn leads to PD. Recently, PD has also increased dramatically, in step with glyphosate usage on corn and soy [Figure 4].

Ironically, while the brainstem suffers from excess Mn, the rest of the brain incurs Mn deficiency due to the depressed serum levels of Mn. Mn is particularly important in the hippocampus, and deficiency there can lead to seizures. A high incidence of seizures is found in children with autism.[302] Seizures are also associated with reduced serum Mn,[54,88,269] and this is consistent with the liver's inability to distribute Mn to the body via the bile acids. Antibiotics have been found to induce seizures.[132]

Mn uptake in the brain is normally enhanced during the neonatal period in rats, and proper development

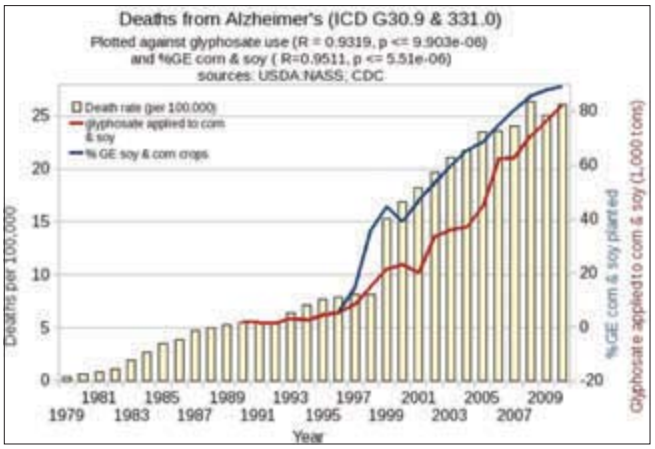

Figure 2: Plots of amount of glyphosate applied to corn and soy crops in the US over time, compared to the rate of death from AD. (Figure courtesy of Dr. Nancy Swanson)

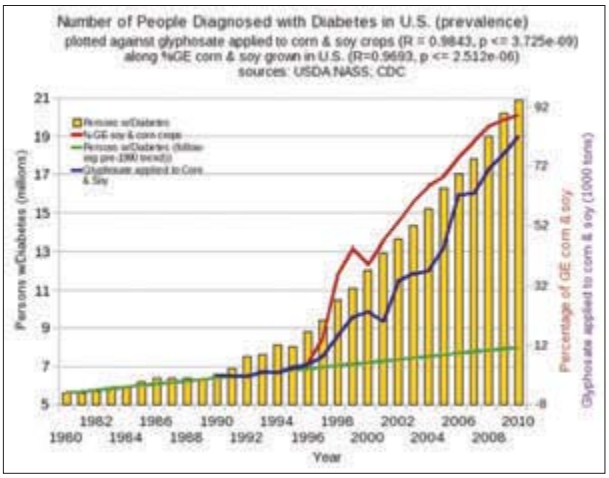

Figure 3: Plots of glyphosate usage on corn and soy crops (blue), percent of corn and soy that is genetically engineered to be "Roundup Ready" (red), and prevalence of diabetes (yellow bars) in the US. (Figure courtesy of Dr. Nancy Swanson)

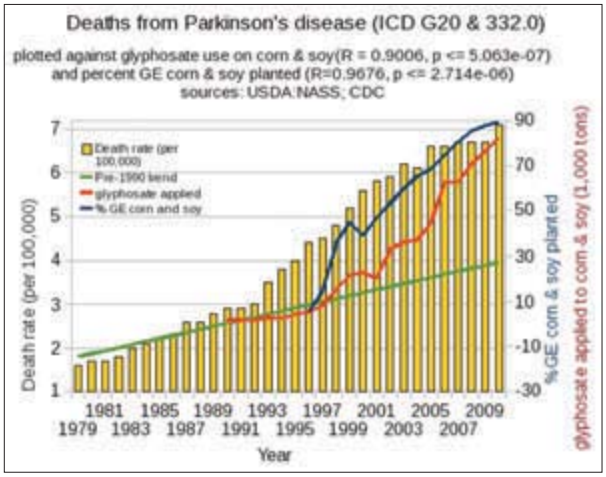

Figure 4: Plots of glyphosate usage on corn and soy crops (blue), percent of corn and soy that is genetically engineered to be "Roundup Ready," (red), and deaths from PD (yellow bars) in the US. (Figure courtesy of Dr. Nancy Swanson)

of the hippocampus depends on Mn.[284] Soy formula increases the risk of seizures in autism,[310] hardly surprising when one considers that soybean crops are now 90% Roundup®-Ready. A recent paper has confirmed that alarmingly high glyphosate residues appear in Roundup®-Ready soy.[35] The US Department of Agriculture analyzed glyphosate residues in soy in 2011, and reported that 91% of the 300 samples tested were positive for glyphosate, with 96% being positive for AMPA, an equally toxic by-product of glyphosate breakdown.[297] Our own analysis confirms that glyphosate is present in infant formula. Out of several soy-based baby formulas we tested, only one contained glyphosate residues. We found levels of 170 ppb in Enfamil ProSobee liquid concentrate. Further testing is underway. Soybean product sourcing and residue testing should be required prior to product manufacturing and is necessary to prevent inadvertent infant exposure.

Another mechanism by which glyphosate in soy formula could cause seizures is through bilirubin production. Serum concentrations of bilirubin were elevated in catfish exposed to sublethal doses of Roundup®, in a dose-dependent relationship.[208] Neonates, due to an immature digestive system, are unable to metabolize bilirubin in the gut, and it can therefore build up in the blood and even penetrate their immature blood–brain barrier to cause seizures.[308]

GLYPHOSATE AND MICROBIAL ANTIBIOTIC INTOLERANCE

Microbial antibiotic tolerance and resistance are a growing problem worldwide, likely fueled by horizontal gene transfer among different bacterial species.[106,121] Multiple-drug resistant commensal bacteria in the guts of both animals and humans form a reservoir of resistance genes that can spread to pathogenic species. Methicillin-resistant *Staphylococcus aureus* (MRSA),[119] *Clostridium difficile*,[183] and *Pseudomonas aeruginosa*[169] are all becoming major threats, especially in the hospital environment. A generic mechanism of upregulated efflux through membrane pores offers broad-domain resistance to multiple antibiotics.[169] Exposure to antibiotics early in life can even lead to obesity as a direct consequence of the resulting imbalance in gut bacteria.[73]

Studies have shown that increased mutation rates due to chronic low level exposure to one antibiotic can induce an accelerated rate of development of resistance to diverse other antibiotics.[151] Glyphosate, patented as an antimicrobial agent,[298] is present in steadily increasing amounts in the GM Roundup-Ready corn and soy feed of cows, pigs, chickens, farmed shrimp, and fish, and it is ubiquitous in the Western diet of humans. *Pseudomonas aeruginosa* can use glyphosate as a sole source of phosphorus,[192] and it is one of a small number of resistant bacterial species with the ability to metabolize glyphosate, a feature that might be exploited for soil remediation.[1] However, DNA mutations due to exposure would enhance tolerance to glyphosate and other antibiotics, perhaps explaining the current epidemic in multiple antibiotic resistant *P. aeruginosa* infections, which have a 20% mortality rate.[190] Antibiotic resistance sequences engineered into GM crops may also play a role in the current crisis concerning antibiotic resistant pathogens.

Glyphosate has also been demonstrated as a remarkable antimicrobial synergist. It greatly increases the cidal effects of other antimicrobials, particularly when combined as salts of glyphosate. A concentration dependent synergy index (SI) ranging from 0.34 to 5.13 has been recorded for the Zn salt of glyphosate.[299] This has serious implications for glyphosate ingested with pharmaceuticals or residues of other widely used agricultural chemicals, such as the herbicides Diquat, Paraquat, 2,4 D and Glufosinate, the fungicide Chlorothalonil and the systemic neonicotinoid insecticides Acetamiprid, Imidacloprid, Thiacloprid, Thiamethoxam, and Clothianidin.

Glyphosate acts as a catalyst for the development of antibiotic resistance genes in pathogens. Since both poultry and cow manure are used as natural fertilizers in crops, it can be expected that a vector for microbial resistance to multiple drugs is through contamination of fruits and vegetables. Indeed, multiple resistance genes have been identified from diverse phyla found in cow manure, including Proteobacteria, Firmicutes, Bacteroidetes, and Actinobacteria, that is, in phylogenetically diverse organisms.[311]

One of the ways in which glyphosate is toxic to plants is through disruption of chlorophyll synthesis, due to suppression of the activity of the first enzyme in pyrrole synthesis.[61,69,143,319] Pyrrole is the core building block of both chlorophyll and the porphyrin rings, including corrin in cobalamin and heme in hemoglobin and cytochrome enzymes. Several cofactors containing a structurally complex tetrapyrrole-derived framework chelating a metal ion (cobalt (Co), magnesium (Mg), iron (Fe), or nickel (Ni)) are synthesized by gut bacteria and supplied to the host organism, including heme and corrin.[236]

Thus, glyphosate can be expected to disrupt synthesis of these biologically essential molecules. Pseudomonas normally thrives in the small bowel and produces abundant cobalamin that may be a significant source for the human host.[6] *P. aeruginosa*'s successful colonization may be due in part to its ability to produce cobalamin despite the presence of glyphosate. Only recently has it also been recognized that a Mn–porphyrin complex can protect from mitochondrial overproduction of hydrogen peroxide (H_2O_2) in response to ionizing radiation.[274] It can be predicted that homeostasis of all of these minerals

in the gut (Co, Mn, Fe, Ni, and Mg) is impaired in the presence of glyphosate, and this will have serious consequences not only to the gut bacteria but also to the impaired regulation of these minerals. The implications of impaired heme and cobalamin synthesis will be further addressed in a future paper.

A key component of glyphosate's action is its ability to chelate minerals, particularly transition metals such as Mn. Glyphosate forms strong complexes with the transition metals via the amino, the carboxylic, and the phosphonic moieties in the molecule. Each of these can coordinate separately to metal ions or in combination as bidentate or tridentate ligands.[194,296]

ANALOGY WITH ARSENIC AND ALUMINUM

Chronic kidney disease is clearly associated with multiple environmental toxicants.[268] There has been an epidemic in recent years in kidney failure among young agricultural workers in Central America, India, and Sri Lanka, particularly those working in the sugar cane fields.[249] A recent paper reached the unmistakable conclusion that glyphosate plays a critical role in this epidemic.[133] A growing practice of spraying sugar cane with glyphosate as a ripener and desiccant right before the harvest has led to much greater exposure to the workers in the fields. The authors, who focused their studies on affected workers in rice paddies in Sri Lanka, identified a synergistic effect of arsenic, which contaminated the soil in the affected regions. This paper is highly significant, because it proposes a mechanism whereby glyphosate greatly increases the toxicity of arsenic through chelation, which promotes uptake by the gut. Glyphosate also depletes glutathione (GSH)[60,128] and glutathione S transferase (GST) is a critical enzyme for liver detoxification of arsenic.[295] As a consequence, excess arsenic in the kidney causes acute kidney failure, without evidence of other symptoms such as diabetes usually preceding kidney failure.

Arsenic is normally disposed of by the liver through biliary excretion. In rats exposed to arsenic, large amounts of GSH appeared in the bile simultaneously with biliary excretion of arsenic.[113] It was first hypothesized, and later confirmed, that arsenic is transported in bile acids in the form of unstable GSH complexes (monomethylarsonous acid), which release GSH upon decomposing. Since glyphosate disrupts CYP enzymes necessary for bile acid formation,[248,249] as well as depleting GSH,[60,128] it can be expected that glyphosate would disrupt the process of biliary excretion of arsenic, thus forcing arsenic to be redirected toward urinary excretion, leading ultimately to kidney failure.

Glyphosate also chelates aluminum,[230] and it has been reasoned that this enables aluminum to get past the gut barrier more readily through direct analogy with the situation with arsenic, which is also a 3+ cation.[193] However, it has been demonstrated through experimentation that glyphosate prefers divalent cations. Thus, aluminum would enter the bloodstream via the digestive tract's portal vein to the organs traveling with albumin, which is known to attach and transport many xenobiotics. It is well established that citrate also binds aluminum and promotes its uptake past the gut barrier through a mechanism that parallels glyphosate's binding to aluminum.[68,148] Both are small molecules that easily pass through a leaky gut barrier.

Considering these observations regarding aluminum and arsenic, it is reasonable to expect that something similar might happen with Mn. Unlike these other two, however, Mn plays many essential roles in the body, and so its chelation by glyphosate would interfere with its bioavailability in the general circulation. Just as for arsenic, bile acids play a critical role in Mn homeostasis. Bile is the major excretory route of injected Mn.[17] Malecki *et al*. wrote: "Biliary excretion may be a major homeostatic mechanism for preventing both deficiency and toxicity of Mn."[179, p. 489]

Glyphosate, a dipolar zwitterion, is toxic in part due to its bio-transformative properties as pH varies. We postulate that Mn, which is transported in the blood stream bound to glyphosate, is oxidized to Mn^{3+} following its release in the localized acidic environment of sulfated glycosaminoglycans (GAGs) in the glycocalyx lining the capillary wall.[234] As we will later explain, Mn uniquely is able to travel along axons and across synapses, and this results in a novel path via the vagus nerve for brain toxicity following excess Mn accumulation in the liver.

Mn is a transition metal, and therefore it can catalyze oxidative reactions in neurons via the Fenton reaction.[305] While Mn^{2+} is the form of Mn that catalyzes enzyme reactions, Mn^{3+}, similar to Al^{3+}, is directly toxic to neuronal membranes.[13] *In vitro* studies have shown that Mn^{3+} complexes auto-oxidize catecholamines, and therefore exposure to excess Mn leads to a decrease in the bioavailability of dopamine, serotonin, and noradrenaline in the striatum.[227]

It has been shown that glyphosate enhances the oxidation of Mn from a 2^+ oxidation state to 3^+, both in solution and on an inert surface.[21] It can be inferred, therefore, that Mn^{2+} oxidation to the toxic form, Mn^{3+}, might occur in the artery wall following exposure to superoxide in the presence of glyphosate. Mn^{3+} also enhances glyphosate degradation to AMPA,[21] which would produce the highly glycating by-product, glyoxylate. Glyoxylate and Mn^{3+} would both cause significant arterial damage in association with the inflammatory response.

We suggest that another route for Mn transport is the vagus nerve, which delivers Mn from the liver to the brainstem nuclei. When bile acid synthesis is impaired,

the brainstem nuclei can acquire neurotoxic levels of Mn, while serum levels are simultaneously depressed.

GUT BACTERIA DYSBIOSIS AND ANXIETY

Anxiety disorder is a comorbidity of autism,[110] AD,[288] and PD,[235] and, in this section, we argue that disruption of Lactobacillus due to impaired Mn bioavailability is a likely cause. Anxiety disorder is also correlated with glyphosate usage on corn and soy, as illustrated in [Figure 5].

Glyphosate has been shown to severely deplete Mn uptake by plants, both by the roots and by the shoots.[127] Experiments on plants demonstrated that Mn applied as fertilizer antagonizes glyphosate's effectiveness in weed control,[29] and this implied that Mn chelation was an important part of glyphosate's toxicity to plants. Electron paramagnetic resonance (EPR) spectroscopy analyses conducted by these authors demonstrated that glyphosate's binding to Mn increased with pH as pH rose from 2.8 to 7.5. The pH of plant symplast is typically 7.5, a level at which glyphosate would be an effective chelator of Mn.

Certain species of gut bacteria, such as members of the Lactobacillus family, utilize Mn in novel ways for protection from oxidation damage, and, as a consequence, their requirements for Mn are much higher than those of other species.[13,14] Thus, Mn chelation by glyphosate would lead to reduced numbers of these essential bacteria in the gut. This leads directly to neurological symptoms such as anxiety, due to the influence of the gut–brain axis.[70,75,106] In the small intestine, the pH increases gradually from pH 6 to pH 7.4 in the terminal ileum.[101] At pH 7.4, Mn bioavailability can be expected to be reduced by 50% due to glyphosate chelation.[173]

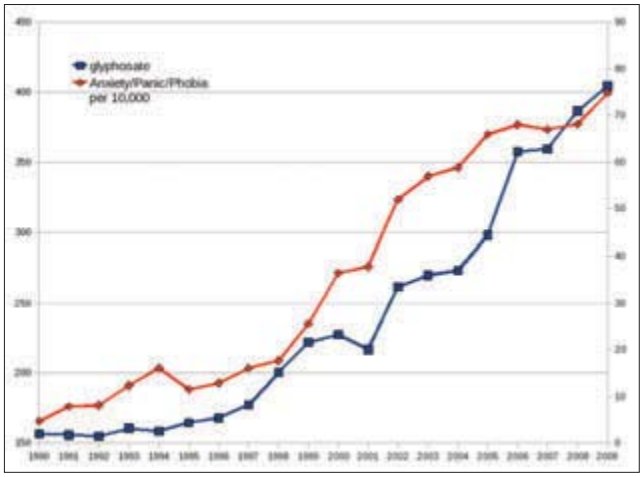

Figure 5: Plots of glyphosate usage on corn and soy crops (blue), provided by the US Department of Agriculture, and rates per 10,000 of phobia, anxiety disorder, and panic disorder (red) in the US, provided by the Centers for Disease Control. (Figure courtesy of Dr. Nancy Swanson)

The liver regulates the amount of Mn in the general vascular circulation, by incorporating any excess into bile acids, which gives the gut bacteria repeated chances to take it up. However, production of bile acids depends upon CYP enzymes, which are disrupted by glyphosate.[248,249] Hence, glyphosate can be expected to lead to severe impairment of Mn bioavailability to the gut bacteria, while at the same time allowing too much Mn to accumulate in the liver.

Lactobacillus tends to reside in the foregut.[286] The pH of the foregut is higher than that of the cecum,[100] so Mn chelation by glyphosate is a bigger issue there, since glyphosate's chelation effects increase with increasing pH. Mn-SOD is an important enzyme in mitochondria for protection from oxidative damage. Most Lactobacillus species lack Mn-SOD, but they have devised a way to protect themselves from oxidation damage due to the superoxide radical by using active transport of Mn in the +2 oxidation state. Many Lactobacilli normally have high intracellular concentrations of Mn.[14] For example, *Lactobacillus plantarum* accumulates over 30 mM of intracellular Mn (II).[13]

A recent study demonstrated that Roundup® in concentrations lower than those recommended in agriculture inhibited microbial growth of three microorganisms that are widely used as starters in fermentation of milk products,[66] including a species of Lactobacillus. Research into genetically engineering an Mn-SOD-encoding gene derived from *Streptococcus thermophilus* into various Lactobacillus species has shown that they can produce Mn-SOD from these heterologous genes and use it to improve their resistance to oxidative stress.[48]

Bruno-Bárcena *et al.*[48] proposed that such genetically engineered Lactobacilli might provide benefit as probiotics to people suffering from colitis or peptic ulcers. Colitis is associated with increased inflammation in the gut, which may be due to impaired function of Mn-SOD. An experiment on a mouse model of colitis demonstrated that *Lactobacilus gasseri* treatment alleviated inflammation in the colon of Il-10 deficient mice.[55] Genetically modified forms of *L. gasseri* as described above, which overproduce Mn-SOD, showed enhanced therapeutic effects.

Several members of the Lactobacillus family are capable of producing the inhibitory neurotransmitter γ-aminobutyric acid (GABA) via the enzyme glutamate decarboxylase, and this may be a reason for their ability to improve symptoms of anxiety. Experiments with Lactobacillus probiotics in mice demonstrated neurochemical and behavioral effects related to changes in GABAergic expression in regions of the brain that control mood.[165] These effects were absent in vagotomized mice, pointing to the vagus nerve as the bacterial communication pathway between gut and brain.

Lactobacillus have been successfully cultivated to produce fermented food containing high levels of GABA, proposed to be a health benefit in probiotics.[40]

Patients suffering from chronic fatigue syndrome (CFS) often have imbalances in microbial flora,[177] along with anxiety as a frequent comorbidity.[104] A pilot placebo-controlled study involved daily administration of *Lactobacillus casei* probiotics over a 2-month period to CFS patients.[232] The outcome was a significant rise in both Lactobacillus and Bifidobacteria in the gut, along with a significant decrease in anxiety symptoms ($P = 0.01$). This study reinforces the gut–brain connection, specifically implicating Lactobacillus in the etiology of anxiety disorder.

MN-SUPEROXIDE DISMUTASE AND MITOCHONDRIAL DYSFUNCTION

Mitochondrial dysfunction, particularly for the neutrophils, which perform important immune system functions, is implicated in CFS,[196] and this could be due to impaired Mn supply to Mn-SOD. Mn-SOD is dramatically upregulated in association with the inflammatory markers tumor necrosis factor α (TNF-α), lipopolysaccharide (LPS), and interleukin-1,[301] presumably to protect mitochondria from oxidative damage. SOD plays an important role in antioxidant defenses, by converting superoxide into H_2O_2, which can then be further detoxified by other enzymes such as catalase.[182] There are three major classes of SOD, which are distinguished by the metal catalyst, which can be copper (Cu), Zn, Mn, iron, or nickel. Eukaryotes rely on a distinct form in the mitochondria, which depends on Mn, whereas Cu/Zn SOD is present in the cytoplasm and extracellularly. Many bacterial species including *Escherichia coli* use Fe-SOD as well as Mn-SOD. The adjuvants in Roundup® may play an important role in enabling glyphosate to penetrate the mitochondrial membrane,[215] where it can interfere with the activities of Mn-SOD via chelation of Mn.

Recent experiments on goldfish involved exposing them for 96 h to Roundup® at concentrations ranging from 2.5 to 20 mg/L.[174] Several metabolites were measured from the liver, kidney, and brain. Remarkably, Roundup® inhibited SOD activity in all three organs examined, by 51–68% in the brain, 58–67% in the liver, and 33–53% in the kidney, and this was the most striking effect that was observed. Unfortunately, they did not specify whether the cytoplasmic Cu/Zn SOD or the mitochondrial Mn-SOD was most affected. Regardless, a plausible explanation of this effect is the chelation of Mn, Cu, and Zn, which are essential cofactors for the two SODs.

A recent study on the fish species *Anguilla anguilla* exposed to environmentally realistic levels of glyphosate over a short time period revealed DNA strand breaks in both liver and gills, along with a suppression of SOD activity in the liver.[116] A plausible explanation is that the breakdown product of glyphosate, glyoxylate, which is a potent glycating agent, would cause DNA damage by attacking Cu, Zn-SOD. Experiments have shown that released Cu in combination with H_2O_2 produced by glycated Cu, Zn-SOD triggers a Fenton reaction, resulting in nuclear DNA cleavage.[138]

Aconitase, an enzyme that converts citrate to isocitrate, is a crucial participant in Complex I of the citric acid cycle in the mitochondria. Many neurodegenerative diseases have been linked to decreased aconitase activity due to oxidative stress, including Friedreich ataxia,[245,249] Huntington's disease,[282] progressive supranuclear palsy,[213] autism,[239] and epilepsy.[300] The presence of a single unligated iron atom in the iron–sulfur cluster of aconitase makes it uniquely sensitive to oxidative inactivation by superoxide.[105] Aconitase inactivation has a cascade effect, because the released iron results in ferrous iron toxicity, further promoting cell death.[52] The pervasive herbicide Paraquat has been implicated in oxidative inactivation of aconitase, and this likely explains its known role in PD.[52]

A postmortem study of brains of autistic individuals showed a striking decrease in aconitase activity in the cerebellum associated with a similar decrease in glutathione redox antioxidant capacity (GSH/GSSG), with the plot producing a near 100% separation between cases and controls.[239] Inadequate clearance of superoxide due to Mn-SOD inactivation can easily account for this observation. Aconitase is a crucial participant in the citric acid cycle in the mitochondria, so this effect has catastrophic consequences on the renewal of adenosine triphosphate (ATP) as an energy source for the neurons.

In another study, cells from children with autism exhibited higher oxidative stress than control cells, including a 1.6-fold increase in reactive oxygen species (ROS) production, 1.5-fold increase in mitochondrial DNA copy number per cell, and more deletions.[198] Furthermore, oxidative phosphorylation capacity of granulocytes from children with autism was 3-fold lower than in controls. These are all indicators of oxidative stress, which could be due to SOD inhibition by glyphosate, mediated by Mn deficiency.

OXALATE

Monsanto's Roundup herbicide, WeatherMax® with Transorb II Technology, is now a preferred formulation and uses a potassium salt of glyphosate (48.8%). The Transorb Technology, which utilizes a dual surfactant system and adjuvants, was first introduced in 1996 as Roundup ULTRA. In 1998, the formula was altered and released as WeatherMAX, then further improved and released in 2005 as the current product.

The inert ingredients have undergone several changes over the years to include formula variations, which included the use of dual surfactants of siloxane copolymers and Polyoxyethylated tallow amine (POEA). As noted by Monsanto, "Promotion of stomatal infiltration of glyphosate by an organosilicone surfactant reduces the critical rainfall period," hence the rain-fastness of Roundup WeatherMax® with Transorb® 2 Technology. In 1995, US Patent #5,464,806 was issued which reflected another product formulation improvement and move from the use of Silwet-77 siloxane surfactant due to phase separation problems, to the use of an acetylenic diol.[142] The new formula provides protection from herbicide loss due to rain within 30 min of application. Additional adjuvants, well known in the paper-making industry, were used to quickly break down cell walls and collapse the plant. These chemicals originally included sodium sulfite with a later change to oxalic acid (oxalate) as patented in 2006.[315] In this patent, it was noted that "it has been discovered that the addition of oxalic acid or salts thereof to glyphosate compositions increases the cell membrane permeability of plant cells or suppresses oxidative burst to increase cellular uptake of glyphosate."

This modification may be related to the recent increase in health issues concerning excess serum oxalate in the United States and elsewhere, linked to both autism and kidney stones. A study comparing children with autism with controls found a 3-fold increase in serum oxalate levels in the children with autism,[152] and it was suggested that this might be due to excess absorption through the gut barrier, and that oxalate crystals in the brain could potentially disrupt brain function. Calcium oxalate crystals are responsible for up to 80% of kidney stones, and there has been an increased incidence of kidney stones recently in the US.[250] In a study on prisoners in Illinois who complained of gastrointestinal distress following a change to a high-soy diet, it was proposed that the unusually high levels of oxalate in the processed soy protein might be responsible for the observed symptoms.[175]

Both the high oxalate content of the soy and the high serum oxalate in humans could be due to impaired oxalate metabolism. Oxalate metabolism by oxalate oxidase in plants and by oxalate decarboxylases in fungi and a few bacteria, such as *Bacillus subtilis*, are both dependent on Mn as a cofactor.[280] Bifidobacteria, which are highly sensitive to glyphosate,[263] possess an oxalate-metabolizing enzyme that depends on magnesium rather than Mn as a cofactor.[102] However, glyphosate decreases the content of both magnesium and Mn in plants.[50] Furthermore, gamma-glutamyl carboxylase, a liver enzyme that metabolizes oxalate, is catalyzed by vitamin K, which depends on the shikimate pathway.[51] It has been shown that patients with calcium oxalate urolithiasis have significantly reduced activity of this enzyme in the liver.[65]

The sulfate ion transporter, Sat-1, plays an important role not only in sulfate transport but also in oxalate transport,[273] as evidenced by the fact that mice with a disrupted Sat-1 gene develop urolithiasis.[252] Glyoxylate is not only a substrate of Sat-1 but it is also a key regulator.[252] The upregulation of SAT-1 by glyoxylate in hepatic cells likely serves to flush oxalate and glyoxylate from the liver, to avoid hepatotoxicity. However, this can lead to nephrotoxicity due to glyoxylate glycation damage and the formation of kidney stones. Due to competition between oxalate and sulfate for transport via Sat-1, glyoxylate, and oxalate, likely, also disrupt sulfate homeostasis in the liver. Sulfate is critical for bile acid formation and for detoxification of xenobiotics such as acetaminophen.

The conversion of glyoxylate to oxalate by the enzyme lactate dehydrogenase is inhibited by oxalate.[87] Hence gloxylate, derived from glyphosate breakdown, would accumulate in the presence of excess oxalate.

Aside from the obvious damaging effects of oxalate crystals on tissues, the oxalate, whose metabolism is impaired due to Mn deficiency, will also interfere with the metabolism of glyphosate, likely greatly increasing both its effectiveness as an herbicide and its toxicity to mammals. Under oxalate stress conditions, both superoxide and the hydroxyl radical are produced in excess amounts.[258] Obviously, the ineffectiveness of Mn-SOD due to Mn deficiency would further enhance the damage due to excess oxalate. SOD activity has been shown to be reduced in association with the urolithic kidney, and methionine supplementation can alleviate this problem.[257] As mentioned previously, methionine is depleted by glyphosate.

AMMONIA, GLUTAMATE, AND NEUROTOXICITY

In this section, we will show that both glutamate and ammonia are implicated as neurotoxins in connection with autism and other neurological diseases, and we will offer the simple explanation that Mn deficiency leads to impaired activity of glutamine synthase and arginase, both of which utilize Mn as a cofactor. Mn deficiency can also explain the increased risk to epilepsy found in autism, due to the fact that Mn decreases T2 relaxation time. Mn-deprived rats are more susceptible to convulsions.[129]

Blaylock and Strunecká[32] have proposed that immune-glutamatergic dysfunction may be the central mechanism of autism spectrum disorders. Ghanizadeh[109] reported that glutamate and homocysteine are elevated in the serum in association with autism, and that glutamine and tryptophan are depleted. Tryptophan, which depends

upon the shikimate pathway in plants and microbes, is the precursor to serotonin and melatonin. An increase in glutamate and a corresponding decrease in glutamine can be entirely explained by an inactive glutamine synthase enzyme. Another extensive study on children with autism compared with controls found low serum tryptophan, high serum glutamate and homocysteine, and significantly reduced free sulfate, as well as high levels of oxidative stress markers,[1] all of which are consistent with these assertions. High serum homocysteine is one associated consequence of folate deficiency:[76] Folate is produced by Lactobacillus and Bifidobacteria from products of the shikimate pathway.[240]

The neurotransmitter glutamate has been implicated as an excitatory neurotoxin in the brain not only in autism but also in association with multiple neurological diseases, including AD, PD, amyotrophic lateral sclerosis (ALS), and multiple sclerosis.[93] Ordinarily, following glutamate release into the synaptic cleft, microglia in the brain take up excess glutamate and convert it to glutamine, using the enzyme glutamine synthase.[204] Glutamine is then released into the extracellular space, taken up by neurons, and converted in the cytoplasm to glutamate to be held within internal vesicles in anticipation of future activity. Conversion to glutamine for the transport stage from microglia to neurons renders the molecule inactive as a neurotransmitter, and therefore as a neurotoxin, when it is out of service.

TNF-α, secreted by activated microglia in the brain, is a major cytokine leading to neurotoxicity in association with multiple neurological diseases. A major component of the damaging effect of TNF-α is the autocrine induction of the release of glutamate from microglia.[285] Experiments exposing immature rats to Roundup®, whether via exposure to the dam during pregnancy and lactation or via acute exposure to the pup for 30 min, demonstrated lipid peroxidation and NMDA receptor activation in the hippocampus, indicative of oxidative stress and glutamate excitotoxicity.[59] Acute exposure increased the release of glutamate into the synaptic cleft, and depleted GSH.

Glutamine synthase depends upon Mn as a cofactor, so depleted Mn supplies would lead to a build-up of glutamate that cannot be returned to the neurons using normal channels. Multiple sclerosis is associated with both depleted Mn in the cerebrospinal fluid[185] and depleted GSH synthase in the white matter lesions.[309] Cerebellar brain samples taken postmortem from 10 individuals with autism demonstrated an anomalous increase in mRNA expression of excitatory amino acid transporter 1 and glutamate receptor AMPA 1, both involved in the glutamate system.[226] Glutamate receptor binding proteins were also abnormally expressed, and AMPA-type glutamate receptor density was low. These effects could be explained as a response to the excess bioavailability of glutamate due to an inability to convert it to the inactive form, glutamine.

Further confirmation of glutamate dysbiosis in autism comes from a study on levels of 25 amino acids in the platelet-poor plasma of high-functioning autistic children compared with normal controls, which revealed that only glutamate and glutamine were abnormally expressed in the children with autism, with a highly significant ($P < 0.002$) excess of glutamate and a highly significant ($P < 0.004$) decrease in glutamine.[264] They linked these findings to glutamatergic abnormalities reported by others.

It is intriguing to us that Mn deficiency leads to a pair of complementary pathologies – excess glutamate along with aconitase deficiency, which together allow for the cells to generate ATP by metabolizing glutamate instead of glucose. Glutamate enters the citric acid cycle beyond Complex I, thus bypassing the step that is impaired by aconitase deficiency. This is a rather elegant regulatory system that provides energy even in the face of Complex I impairment.

The prevalence of epilepsy in the US is similar to that of diabetes, making it a common disorder affecting 2 million Americans.[47] Epilepsy is associated with increased T2 relaxation time in nagnetic resonance imaging (MRI) signaling analysis of the hippocampus, both in the ipsilateral sclerotic hippocampus as well as the contralateral hippocampus and anterior temporal lobe.[42] Following intracerebral injection of Mn, a large amount of Mn accumulates in the hippocampal fissure, which results in a reduction in T2 relaxation time.[78] Epilepsy may therefore be a consequence of insufficient Mn in the hippocampus, which could easily account for the associated increase in T2. Autism is associated with a high risk of epilepsy,[293,162] and the hippocampus has been the focus of many studies on the neurological pathology of autism.[84,95]

Ammonia is a well-established neurotoxin, which accumulates when the urea cycle is unable to keep up with ammonia released from protein breakdown.[290] Ammonia can induce tremor, ataxia, seizures, coma, and death.[49] Ammonia is a highly diffusible gas that readily crosses the blood–brain barrier, and its detoxification depends upon the conversion of glutamate to glutamine, which is catalyzed by glutamine synthase, the enzyme in microglia that relies upon Mn as a cofactor.[71] Thus, impaired function of glutamine synthase leads to the accumulation of both glutamate and ammonia in the brain, both of which are established neurotoxins.

Excess ammonia due to impaired ability to detoxify excess nitrogen via the urea cycle can lead to impaired memory, shortened attention span, sleep–wake cycle disruption, brain edema, intracranial hypertension, seizures, ataxia,

and coma.[37] Arginase, the final enzyme of the urea cycle, is ubiquitous in living systems, and depends upon Mn as a cofactor. Therefore, Mn deficiency due to glyphosate's chelation of the metal would be expected to lead directly to impaired arginase function. The excess accumulation of ammonia due to inactive glutamine synthase combined with the decreased ability to metabolize ammonia to urea constitute a double-hit leading to ammonia toxicity in the brain.

A case study of a 4-year-old girl showed that a genetic defect in arginase could present as pervasive developmental delay not otherwise specified (PDD-NOS) with many similarities to autism.[112] Its manifestations include brain edema and signs of epilepsy, as would be expected with ammonia toxicity in the brain. A Mn-deficient diet administered to rats induced a reduction in hepatic arginase activity ($P < 0.01$), along with a significant rise in plasma ammonia ($P < 0.01$).[43]

Seneff *et al.*[260] put forward the idea that excess ammonia due to disrupted gut bacteria could lead to a chronic low-grade encephalopathy that could explain much of the pathology associated with autism. Furthermore, glyphosate is known to induce excess ammonia production in plants, due to overactivity of the enzyme phenylalanine ammonia lyase (PAL).[86,117,125] This enzyme may also be overactive in gut bacteria exposed to glyphosate, further compounding the problem.

CHOLESTASIS AND BILIRUBINEMIA

Mn stimulates cholesterol synthesis in the liver, presumably because bile acids, derived from cholesterol, are needed to bind to Mn and carry it back to the gut for recycling.[5] However, CYP enzyme inhibition will impair the liver's ability to oxidize cholesterol, since the formation of oxysterols in the liver for incorporation into bile acids depends on several CYP enzymes (members of the CYP3, CYP7, CYP8, CYP27, CYP39, and CYP46 families).[200,217] As a result, it can be anticipated that, when Mn supplies are plentiful, both the Mn and the cholesterol will accumulate to toxic levels in the liver, unless another method can be found for their redistribution. In the case of cholesterol, this may lead to a necessary increase in the synthesis and release of LDL particles. People with a defective CYP7A1 gene have significantly elevated total and LDL cholesterol levels, as well as substantial accumulation of cholesterol in the liver and a markedly decreased rate of bile acid excretion.[225] Neonatal cholestasis and hypercholesterolemia (elevated LDL) were produced in mice with a defective CYP7A1 gene fed a normal chow diet.[96] The increased serum levels of LDL associated with heart disease risk may therefore be a consequence of the production of cholesterol that cannot be exported through the biliary ducts.

Studies with rats have shown that *Lactobacillus plantarum* probiotic supplements lower serum LDL levels.[166] Lactobacillus levels were reduced in chickens exposed to antimicrobial drugs, which resulted in reduced bile salt deconjugation in the gut.[114] Impaired bile salt deconjugation by gut bacteria results in significant weight gain along with elevated plasma cholesterol and liver triglycerides in mice.[136] Thus, glyphosate acting as an antibiotic that preferentially kills Lactobacillus can be expected to lead to elevated serum cholesterol and triglycerides through a similar mechanism.

Cholestasis is a blockage of bile acid flow, which often occurs as a side effect of various pharmaceutical drugs.[211] Glyphosate administration to rats over a period of 13 weeks induced increases in serum bile acids, indicative of cholestasis.[64] Severe cholestasis can induce bilirubinemia,[28] and glyphosate also independently induces bilirubinemia in catfish.[208] At least two other studies have shown bile stagnation in fish exposed to glyphosate.[80,135]

Inflammatory bowel disease (colitis and Crohn's disease) has been increasing in frequency in the US over the past 20 years, in step with glyphosate usage on corn and soy crops, as shown in [Figure 6]. According to analyses by Cappello *et al.* in a hospital-based survey,[53] cholestasis is a common feature of inflammatory bowel disease. They observed a cholestatic pattern in 60% of patients studied, mainly related to older age, longer duration of disease, and hypertension. Gallstones were commonly found, often in association with abnormal bile salt absorption, especially in Crohn's disease patients.

Ironically, while Mn-SOD depends upon Mn as a cofactor, *excess* exposure to Mn can inhibit SOD expression. Experiments exposing rats to excess Mn revealed several

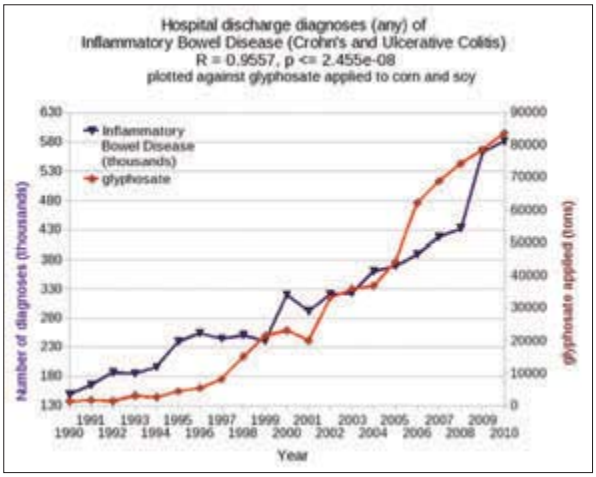

Figure 6: Plots of glyphosate usage on corn and soy crops (blue), and hospital discharge diagnoses of inflammatory bowel disease (Crohn's andulcerative colitis) in the US, over time. (Figure courtesy of Dr. Nancy Swanson)

pathological effects on the liver, including inhibition of SOD and GSH peroxidase, as well as decreased levels of GSH and reduced levels of sodium-potassium ATPase activity.[126] It is striking that glyphosate has also been shown to have these very same effects in animal experiments,[60,174,89] and it is conceivable that these effects may be in part mediated by excess Mn accumulation in the liver.

Bilirubinemia in neonates is a risk factor for autism, particularly when it is unbound and unconjugated.[10] Glucose 6-phosphate dehydrogenase (G6PD) deficiency can induce bilirubin toxicity in neonates,[176] due to the fact that G6PD enables conjugation of bilirubin.[141] Glyphosate was shown to induce a 2.67-fold reduction in G6PD expression in *E. coli*.[171] Studies on goldfish demonstrated that glyphosate significantly decreased G6PD activity in liver, kidney, and brain.[174]

G6PD is the main enzyme responsible for regeneration of NADPH, an essential requirement for GSH reductase activity.[174] Cholestasis is associated with a reduction in the supply of reduced GSH.[317] Furthermore, glyphosate has been shown to reduce the activity of GSH reductase in the liver.[174] Preeclampsia, affecting 4% of pregnancies, is associated with G6PD deficiency in red blood cells along with a reduction in reduced GSH.[3] The ratio of oxidized to reduced GSH is consistently high in association with autism, in plasma, immune cells, and the brain.[239]

A mouse model of cholestasis can be induced by exposing mice to Mn, followed shortly by exposure to bilirubin.[82] Mn induces cholesterol synthesis in the liver, and bilirubin disrupts 7-α oxidation of cholesterol, a crucial step in bile acid formation.[5] Cholesterol 7-α hydroxylase is the CYP enzyme CYP7A1 and is likely disrupted independently by glyphosate. Therefore, excess Mn in the liver works synergistically with glyphosate to induce cholestasis.

The incorporation of cholesterol products into exported bile acids is crucial for regulating cholesterol homeostasis.[205] Bile acid transport depends on ATP,[203] so mitochondrial disruption due to oxidation damage consequential to excess Mn could contribute to disturbed bile acid export, leading again to cholestasis. *In vitro* experiments exposing rat H9c2 cells to glyphosate plus the surfactant TN-20, which is a polyoxyethylene tallow amine commonly used in glyphosate herbicides, demonstrated that the surfactant in conjunction with glyphosate causes collapse of the mitochondrial membrane potential, leading to necrosis and apoptosis.[147] Even in the absence of a catastrophic death cascade, a drop in mitochondrial membrane potential would obviously negatively impact ATP production. The effect could be due in part to polyoxyethylenealkylamine (POEA), which includes polyethoxylated tallow amine surfactants that enable glyphosate to penetrate the mitochondrial membrane.[188] But, in addition, excess Mn, which would accumulate due to the lack of bile flow, itself induces a collapse in mitochondrial membrane potential.[137]

Intracellular accumulation of bile acids, associated with cholestasis, is known to be toxic to hepatocytes. The accumulation of bile acids in the cholestatic liver induces oxidative stress and apoptosis, resulting in damage to the liver parenchyma, and, ultimately, extrahepatic tissues as well.[180] The lipophilic bile acids are much more damaging than the hydrophilic ones,[15] and they can induce proton leakage and the permeability transition pore (PTP), resulting in programmed cellular death.[237] Their toxic effect is directly due to their role as surfactants.[180] Therefore, they enhance the effects of the surfactants in Roundup®, acting in a cascade reaction.

On the other hand, the hydrophilic bile acid, ursodeoxycholic acid (UDCA), is protective, and its protective effects have been proposed to be due to its ability to induce the expression of CYP3A4, a bile-metabolizing enzyme, in hepatocytes.[11] Hydroxylation, which depends on CYP enzymes, converts lipophilic compounds into hydrophilic products. So one can expect that, in the context of the CYP-enzyme suppressing effects of glyphosate, [248,249] lipophilic bile acids would accumulate in hepatocytes, and their export would be impeded by the loss of ATP subsequent to mitochondrial damage, in a positive feedback loop.

Another enzyme class that was discovered to be downregulated in the liver by glyphosate in the goldfish study is GST, an important class of enzymes. The main function of the GST enzymes is the detoxification of electrophilic xenobiotics by GSH conjugation.[275] Beyond their important role in the detoxification of xenobiotics, gene variants where the enzyme is inactive are associated with increased risk to basal cell carcinoma, and a gain-of-function mutation leads to decreased risk to asthma.[275] Arsenic, whose toxicity is synergistically enhanced by glyphosate[132] is a risk factor for basal cell carcinoma.[62] Asthma is reaching epidemic proportions today[91] and is associated with autism.[24,25] GST is increasingly recognized as an important enzyme in gut bacteria, which allows them to assist in the detoxification of xenobiotics.[7]

One final factor in cholestasis is vitamin K deficiency, which is associated with cholestatic liver disease.[278] Chorismate, the intermediary in the shikimate pathway whose synthesis is blocked by glyphosate, is a precursor not only for the three aromatic amino acids but also for tetrahydrofolate and phylloquinone (vitamin K1) in plants.[294] Similarly, menaquinone (vitamin K2) is synthesized by bacteria from chorismate.[27] Thus, disruption of the shikimate pathway contributes to vitamin K deficiency, which can lead to cholestasis.

SALMONELLA INFECTION

Multiple drug-resistant strains of Salmonella are becoming an increasing problem both in the industrialized[191] and in the developing world.[246] This may be due in part to the fact that Salmonella is more resistant to glyphosate than other species. *Salmonella typhimurium* is among a small set of microbes that possess phosphonatase genes that allow it to use the commonly occurring natural phosphonate, 2-aminoethyl-phosphonate (AEPn), as a sole source of phosphorus,[134] which likely contributes to its growth advantage in the presence of the phosphonate, glyphosate. Furthermore, Lactobacillus, which are especially vulnerable to glyphosate, produce antimicrobial compounds that can defend against Salmonella.[81] Salmonella infections often originate from contamination of plant-based foods exposed to manure of chickens and pigs. A study on poultry showed that *Salmonella entritidis*, *Salmonella galliarum*, and *Salmonella typhimurium* were all highly resistant to glyphosate compared with other more benign species.[263]

Our research into the pathology of Salmonella has uncovered a complex interplay of many factors that may be responsible for the epidemic, which includes an important role for Mn, as well as a role for industrial processing of lecithin from soy, and bile acid disruption by glyphosate. Commercial lecithin is a mixture of phospholipids and various metabolites, often derived from soy. In food processing, phospholipase A (PLA) is applied enzymatically to hydrolyze phospholipids in lecithin into lysophospholipids and fatty acids, in order to improve its emulsification, surfactant, and lubricant properties.[97] This may be a factor in inducing both increased virulence and an inflammatory response to Salmonella in the gut, contributing to inflammatory bowel disease.

Salmonella depend on cyclic adenosine monophosphate (cAMP) for flagella formation, and therefore for motility.[318] Salmonella possess a lysophospholipid sensing mechanism that triggers the synthesis of flagellin, mediated by cAMP, and this activates toll-like receptor 5 (TLR5) in macrophages, inducing an inflammatory response.[279] Experiments have shown, as might be expected, that flagella, produced from flagellin, not only enhance mobility but also protect *S. typhimurium* from internal death in macrophages and enhance their ability to multiply within an infected cell.[306]

Salmonella are remarkably resilient in an inflammatory environment, and, in a novel strategy for survival in a hostile environment, they take advantage of tetrathionate produced from oxidation of thiosulfate by ROS as a terminal electron acceptor in processing ethanolamine derived from host lysophospholipids as a source of energy not available to other microbes.[8,313] They can also uniquely use a glycated L-asparagine (fructose-asparagine, F-asn) as a source of both carbon and nitrogen.[8] Concentrations of F-asn, an Amadori product, are surprisingly high in heated fruits and vegetables.[92]

It has only recently been appreciated that Mn plays an important role in the virulence of Salmonella.[144] Salmonella depend on Mn to resist the oxidative attack of macrophages via Mn-SOD.[292] Since glyphosate's chelation of Mn makes it unavailable to gut bacteria, a mystery arises as to how Salmonella might acquire adequate Mn for defense against oxidative damage. Salmonella possess a Mn uptake system based on a protein that is homologous to eukaryotic Nramp transporters. This protein, MntH, is a proton-dependent metal transporter that is highly selective for Mn^{2+} over Fe^{2+},[144] or any other cation. Intracellular Mn^{2+} can accumulate in millimolar amounts even when environmental Mn^{2+} is scarce.

A feature unique to Salmonella is that they are especially adept at binding to cholesterol in the gall bladder, particularly in association with gallstones, and they also possess adaptive responses that allow them to survive the harsh environment of the bile acid milieu, as well as the highly acidic environment of the stomach.[9] In fact, studies have shown that they can survive a lower pH environment than either Shigella flexneri or *E. coli*.[167]

Several different species of Salmonella can form biofilms on human gallstones, which is dependent upon the presence of bile.[222,74] Since bile is an excellent source of Mn, and glyphosate's chelation of Mn is dependent on a basic environment, they could accumulate Mn while resident in the bile acids present in the gallstones. Bile acids offer antibacterial defenses, but Salmonella have developed resistance genes to protect them from bile acids.[123] In association with gallstones, *S. typhi* colonize the human gallbladder and persist in an asymptomatic carrier state.[9,187] Thus, impaired bile acid flow due to glyphosate would promote both gallstones and microbial growth.

Fibrates are hypolipidemic agents that are known to suppress bile acid synthesis via suppression of peroxisome proliferator-activated receptor γ (PPAR-γ).[220] Studies on humans exposed to fibrates have shown reduced activity of cholesterol 7α-hydroxylase (CYP7A1), leading to reduced bile acid production, and concurrent increased risk of gallstones.[271,31] Thus, it is plausible that Salmonella are able as well to gain a foothold on the gallstones caused by suppression of bile-acid production by glyphosate due to CYP enzyme inactivation, and they are able to take up Mn in the immobilized bile acids and utilize it for Mn-SOD production, protecting them from oxidative attack by macrophages. The pathogen responsible for Lyme disease, *Borrelia burgdorferi*, is also uniquely dependent on Mn,[4] and the disruption of Mn homeostasis by glyphosate may therefore play a role in its emergence.

CHONDROITIN SULFATE, OSTEOMALACIA AND ARTHRITIS

Vitamin D deficiency has reached epidemic proportions in the US and increasingly around the world in recent years.[124] In a large population study in the US, Bodnar *et al*.[34] found deficient levels of vitamin D in 83% of Black women and 92% of their newborns, as well as in 47% of White women and 66% of their newborns, despite the fact that over 90% of the women were on prenatal vitamins. This deficiency is associated with an increased risk to bone fractures, likely due to impaired calcium homeostasis.[145] It is even likely that care-takers are being falsely accused ("Shaken Baby Syndrome") of abusing children in their care who suffer from bone fractures.[255] These children are highly vulnerable to bone fractures due to impaired bone development. Bone fractures in the elderly due to osteoporosis have also risen sharply recently in the industrialized world.[139] The cause of a surging incidence of hip fractures across multiple age groups remains a mystery to medical personnel.[140]

Samsel and Seneff[248,249] proposed that the current vitamin D deficiency epidemic is caused by glyphosate, due to glyphosate's interference with CYP enzymes. The metabolite that is usually measured, 25-hydroxy vitamin D, is the product of activation in the liver by a CYP enzyme that is also critical in bile acid formation. However, there is a larger problem with bone development due to impaired Mn homeostasis. Bone mineralization depends critically on Mn, due to its essential role in chondroitin sulfate synthesis.[36,158] Several enzymes in the osteoblasts needed for this crucial step in bone development require Mn as a cofactor, including the polymerase, which polymerizes uridine diphosphate N-acetyle-galactosamine (UDP-N-acetyl-galactosamine) and UDP-glucuronic acid to form the polysaccharide, and galactotransferase, which incorporates galactose from UDP-galactose into the trisaccharide that links the polysaccharide to the glycosylated protein.[157,158] Chondroitin sulfate, together with osteocalcin, forms the ground substance to which collagen adheres to maintain healthy bone, ligaments and cartilage. Sulfate uptake by GAGs in chicks fed a Mn deficient diet was only 50% of that in control chicks, and the deficient chicks suffered from growth retardation and skeletal abnormalities.[36]

Osteoarthritis is another pathology likely related to Mn deficiency, impaired chondroitin sulfate synthesis and impaired vitamin D activation. Vitamin D deficiency is associated with rheumatoid arthritis.[207] Mn is necessary for the synthesis of GAGs or mucopolysaccharides,[156,254] which provide lubrication and protection for the joints. Rheumatoid arthritis is associated with Mn accumulation in the liver,[72] which is consistent with impaired bile flow. Glucosamine sulfate has been demonstrated to be effective in treating osteoarthritis, and it may even delay disease progression.[259] A combination therapy of glucosamine, chondroitin sulfate, and Mn ascorbate was shown to be effective in treating knee osteoarthritis in a placebo-controlled study conducted on US Navy specialists.[160]

A mysterious epidemic of a new disease, called "sea star wasting syndrome," is currently sweeping across the Pacific coast of North America, affecting at least 12 different species of sea stars.[307] We highly suspect that glyphosate plays an important role in this disease, and that it does so by chelating Mn, and therefore disrupting chondroitin sulfate synthesis. A likely source is Roundup® applied to oyster beds to kill the invading sea grass, since oysters are a common food for sea stars.[118] The state of Massachusetts was forced to close oyster beds in Edgartown on Cape Cod recently, due to infection with a pathogen, *Vibrio parahaemolyticus*.[214] This species synthesizes an N-acetyl transferase (NAT) protein, which is capable of detoxifying glyphosate by acetylating the nitrogen moiety,[58] and this could explain its overgrowth as being linked to glyphosate contamination. An analysis of the GAGs isolated from brittle stars showed exceptionally high proportions of di- and trisulfated chondroitin sulfate/dermatan sulfate disaccharides,[233] whose synthesis would be severely impaired by Mn deficiency due to chelation by glyphosate.

A protective layer of mucopolysaccharides called mucus is secreted by corals, and it has been characterized as containing sulfated glycoproteins similar to chondroitin sulfate,[44] which play an important role in controlling pH and the transepithelial movement of electrolytes and water, just as is the case in vertebrate mucosa. Mucus pathology is implicated in coral disease leading to mortality, particularly in the Caribbean.[219] Thus, an interesting hypothesis that should be considered is that glyphosate chelation of Mn is a crucial factor in the worldwide coral die-off.

PARKINSON'S DISEASE

It might be anticipated that a simple Mn mineral supplement could correct for the problem of glyphosate's chelation of Mn, but this assumption is almost certainly false. We suggest that glyphosate's disruption of Mn homeostasis leads to extreme sensitivity to Mn bioavailability, making it easy to err in the direction of either too little or too much.[103] Our investigations into the body's mechanisms for transporting Mn has revealed a likely pathway from the liver to the brain that would induce Mn toxicity in the brainstem nuclei whenever Mn is plentiful but glyphosate is also present. A strong clue comes from the condition, "manganism," closely resembling PD, which develops following

chronic occupational exposure to airborne nanoparticles containing Mn.[163,172,244] In addition to evidence from direct occupational exposure, geographical studies in the US have shown a higher incidence of PD in urban areas with higher industrial release of Mn.[312]

The fact that death from PD has increased in the past two decades in step with glyphosate usage on corn and soy suggests that there may be a role for glyphosate to play in Parkinson's pathology [Figure 4]. A case of accidental acute exposure to glyphosate through skin contact showed a remarkable development of Parkinsonian symptoms beginning just 1 month following exposure.[20] T2-weighted images revealed a hyperintense signal in the globus pallidus and substantia nigra. Another case study involved a 44-year-old female who developed PD after a 3-year period of job-related exposure at a chemical plant.[304] Glyphosate has also been shown to induce Parkinsonian-like effects in the worm, *Caenorhabditis elegans*, characterized by damage to both GABAergic and dopaminergic neurons.[201] The mechanism behind this effect remains obscure. However, a Mn-containing fungicide, MANCOZEB, ethylene bisdithio-carbamate, also induced similar damage.

An experiment where rats were exposed to Mn via intranasal instillation demonstrated that the Mn could enter the brain through the olfactory bulbs by following major neuronal pathways.[291] Mn migrated via both secondary and tertiary olfactory pathways and beyond to ultimately reach most parts of the brain and the spinal cord. By contrast, cadmium was unable to pass through synaptic junctions and was therefore limited in its penetration. These authors concluded that the olfactory nerve is the likely pathway by which Mn gains access to the brain in manganism, thus circumventing the blood–brain barrier. Autoradiographic studies tracking the distribution of radiolabeled Mn injected into rat brain verified that Mn is subject to widespread axonal transport in neuronal circuits.[283]

Elder *et al*.[94] reinforced this idea, in a study involving exposure of rats to ultrafine particles (UFPs) of inhaled Mn oxide. Their conclusion sums up the situation quite well: "We conclude from our studies that the olfactory neuronal pathway represents a significant exposure route of central nervous system (CNS) tissue to inhaled solid Mn oxide UFPs. In rats, which are obligatory nose breathers, translocation of inhaled nanosized particles along neurons seems to be a more efficient pathway to the CNS than via the blood circulation across the blood–brain barrier. Given that this neuronal translocation pathway was also demonstrated in nonhuman primates, it is likely to be operative in humans as well." [94, p. 1178]

Manganism is distinct from PD mainly in that it is the locus coeruleus that is preferentially damaged rather than the substantia nigra.[216] In the rat, at least 40% of all locus coeruleus neurons project to the olfactory bulb.[266] Since glyphosate likely interferes with the normal recycling of Mn via the bile acids, the liver will need to find an alternative route to dispose of excess Mn. Following the example of nerve-fiber migration from the olfactory bulb,[291] and the study on injected Mn,[283] a likely path is the vagus nerve, which has extensive innervation in the liver, with 10 times as many afferent nerves as efferent nerves, and particularly concentrated on the outer surface of the bile ducts.[30] MRI abnormalities indicative of Mn toxicity in the globi pallidi and substantia nigra were noted in three cases of patients with liver disease.[120] PD is associated with nonmotor symptoms that often precede the movement impairment aspects.[320] These include depression and gastrointestinal disturbances.

Berthoud *et al*.[30] proposed that the onset of PD may be associated with impairment of the vagus nerve, and subsequent functional inhibition of the dopamine system. Clinical trials have revealed pathological alteration of the vagus nerve in PD patients.[218] The dorsal motor nucleus of the vagus is an early site of pathology.[38] Liver failure can lead to excessive build-up of Mn in the brainstem, particularly the globus pallidus in the basal ganglia, which regulates voluntary movement. This is due primarily to decreased billiary excretion from the liver,[99,131] as bile acids recycle Mn back to the gut, where it is taken up by gut bacteria or disposed of. Liver cirrhosis is associated with excess Mn in the brain and associated Parkinsonian symptoms.[99] Mn neurotoxicity in the basal ganglia causing Parkinsonian symptoms has also been identified in association with chronic liver failure.[150] Despite the fact that Mn is an essential cofactor for glutamine synthase, excess Mn actually downregulates expression and activity of the enzyme, causing neuropathology. Its toxicity is linked to disruption of the cycling between astrocytes and neurons of glutamine, glutamate, and GABA.[267] Mn inhibits ATP-dependent calcium signaling in astrocytes, which likely contributes to the toxic effects of excess Mn on neurons.[277] Decreased bile flow associated with the birth defect, biliary atresia, leads to Mn accumulation in the liver[23] and in the globus pallidus.[130] As discussed previously, bile acid synthesis and export are disrupted by glyphosate and by surfactants, which is also a common effect of many toxic chemicals whose detoxification would be impaired by glyphosate's disruption of CYP enzymes.[248]

A study using MRI technology to detect Mn distribution in the brain in marmosets and rats following Mn injections revealed an accumulation in the basal ganglia as well as other parts of the brain that were situated near the ventricles, suggesting redistribution via the cerebrospinal fluid.[33] There was also considerable liver damage, especially in the marmosets, including hemosiderosis, congestion, and hepatic necrosis. Marmosets were far more susceptible than rats to Mn toxicity.

Both the substantia nigra and the locus coeruleus are characterized by high concentrations of neuromelanin. While it is unclear what role neuromelanin plays, one hypothesis is that it carries a protective action through its unique ability to accumulate and retain various amines and metallic cations, especially Mn.[168] The neuromelanin produced by the substantia nigra is closely related to dopamine, and therefore derived from tyrosine. The locus coeruleus' melanin is related to noradrenaline, and therefore derived from tryptophan. Both tyrosine and tryptophan are products of the shikimate pathway, and are therefore likely to be deficient in the context of glyphosate exposure to plants and microbes. This would result in a reduced ability to temporarily house excess Mn in the brainstem nuclei until it can be disposed of.

Glyphosate itself likely also contributes directly to PD. PD is caused by degeneration of dopaminergic neurons in the substantia nigra, attributed to mitochondrial dysfunction, oxidative stress, and protein aggregation.[79,251] PC12 cells are a popular model cell line for investigating neurological disease, and they produce dopamine in vesicles, as is appropriate for cells from the substantia nigra. A study on PC12 cells exposed to glyphosate demonstrated that glyphosate induced cell death via autophagy pathways as well as apoptotic pathways.[115]

A study on serum Mn levels in infants and their association with neurodevelopment revealed a U-shaped curve, with both too little and too much Mn leading to impaired development.[67] This study was conducted on children born in Mexico City between 1997 and 2000. We hypothesize that extreme sensitivity to Mn levels can be expected in the context of glyphosate, because it would prevent the liver from disposing of Mn via the bile acids, and therefore cause a flooding of the brainstem nuclei with excess Mn delivered via the vagus nerve. At the same time, Mn uptake into the blood stream from the gut is suppressed, both because of glyphosate's chelation of Mn at higher pH and the impaired recycling to the gut from the liver. This can lead to a paradoxical situation in which the brainstem nuclei are overwhelmed with Mn while the precortex and cortex are deprived because of the low bioavailability from the blood stream. One might postulate that seizures play a role in enhancing Mn redistribution from the brainstem to the cortex by mobilizing Mn transport along axons, and this effect might therefore explain the benefit of electroconvulsive therapy (ECT) to depression.[16]

Dopamine suppresses thyroid stimulating hormone, and therefore dopamine insufficiency can lead to overactive thyroid and potential burnout of the thyroid gland.[270] This problem is compounded by the fact that thyroid hormone itself is derived from tyrosine, one of the three aromatic amino acids that are negatively impacted by glyphosate through disruption of the shikimate pathway. The thyroid gland also depends critically on selenoproteins as antioxidants.[249] Glyphosate's depletion of both selenium and methionine will lead to reduced bioavailability of selenoproteins. It is conceivable that all of these factors working together can explain the strong correlation of glyphosate application to corn and soy with thyroid cancer [Figure 7], as well as the association between maternal thyroid disease and autism.[238]

PRION DISEASES AND MANGANESE

Prions are a special class of proteins that acquire alternative conformations that can become self-propagating. There is a class of neurological diseases called transmissible spongiform encephalopathies that are believed to be caused by misfolding of prion proteins, predominantly accumulating in the gray matter in the brain.[223] These include Creutzfeldt–Jakob disease (CJD) in humans, scrapie in sheep, chronic wasting disease of deer, and bovine spongiform encephalopathy or Madcow disease.

Prion proteins have been shown to bind Cu *in vivo*,[46] and this is probably an important factor in their normal functioning. Cu protects against conversion of prions to the pathogenic form, and studies have shown that gene variants with extra octarepeat inserts exhibit decreased Cu binding in association with markedly increased disease risk.[272] A theory first proposed by Purdey[228,229] is that the prion protein misfolds following binding to Mn instead of Cu. The pathology is then explained by a high Mn to Cu ratio in the diet. Brown *et al*.[45] investigated metal binding properties of prion proteins, and demonstrated that prions only bind to Cu and Mn. Furthermore, Mn binding induces a resistance to protein degradation by

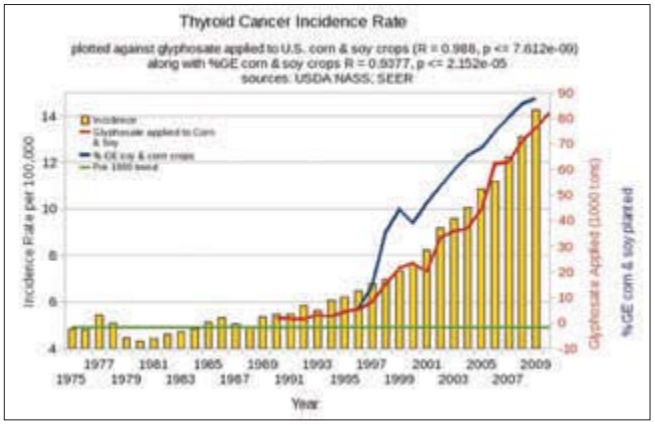

Figure 7: Plots of glyphosate usage on corn and soy crops (blue), percent of corn and soy that is genetically engineered to be "Roundup Ready" (red), and incidence of thyroid cancer (yellow bars) in the US. (Figure courtesy of Dr. Nancy Swanson)

protease, a characteristic feature of prion diseases. Aging of the Mn-bound version of prion proteins leads to loss of function. A later experiment demonstrated that Mn promotes prion protein aggregation.[161] Thus, Mn is causal in the formation of fibrils characteristic of the scrapie isoform of the protein in prion diseases.

The possible link between excess Mn and prion diseases was also supported in a later study by Masánová *et al*.,[181] who compared different regions of the Slovak republic and found a correlation between an elevated Mn/Cu ratio in core food items such as potato and bread, as well as in the soil, and a higher incidence of CJD.

Mn-SOD-/- mice die between days 3 and 13 following birth. They exhibit a marked dilated cardiomyopathy, neurodegeneration and fatty liver disease.[159,164] Mn 5, 10, 15, 20-tetrakis (4-benzoic acid) porphyrin (MnTBAP) rescues mice from this pathology and dramatically improves their lifespan. It operates at 10% of the efficiency of Mn-SOD to oxidize superoxide to H_2O_2. However, these supplemented mice develop a spongiform encephalopathy very similar to CJD.[186] This is most likely caused by excess delivery of Mn to the brain by the MnTBAP.

Purdey[227] has noted that madcow disease epidemiology aligned with the regulatory requirement to apply the organo phthalimido-phosphorus insecticide, phosmet, on the backs of cattle, for the control of warble fly during the 1980s. He maintained that phosmet chelated Cu in the CNS, but also caused oxidation of Mn to Mn^{3+}, leading to its toxicity. Like glyphosate, phosmet also disrupts CYP enzyme function,[262] which would lead to a similar disabling of bile acids.

New experimental data support the idea that the class of prion diseases should be expanded to include AD, PD, and related tauopathies.[224] Indeed, it has been proposed that Cu deficiency may be a factor in AD.[149] Glyphosate chelates Cu down to much lower pH values than those at which it chelates Mn [173,296] [Figure 8], and it has also been shown to oxidize Mn to the +3 oxidation state.[21] Thus, one can surmise that glyphosate might behave similarly to both phosmet and MnTBAP to be causal in prion diseases. In the pH 4 environment adjacent to the sulfates in the glycocalyx, Mn, but not Cu, would be released by glyphosate. Abundant bioavailability of Mn^{3+} alongside Cu deficiency further aggravated by glyphosate could set up a situation whereby excess Mn supplied to the neurons in the cortex, bound to glyphosate, over-competes with Cu in binding to prion protein. One can predict that glyphosate's tenacious binding to Cu will render Cu systemically unavailable, which argues for a role for glyphosate in prion diseases through Cu binding.[45,228,229]

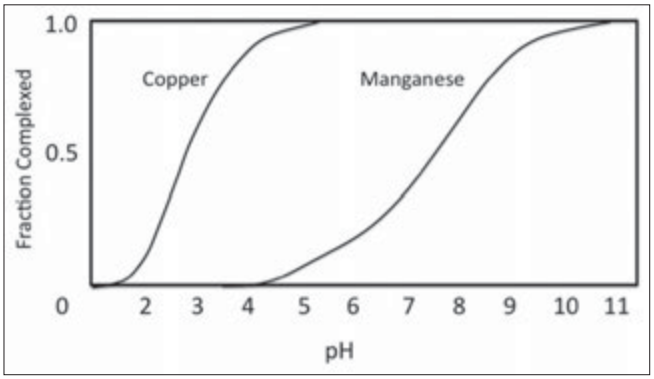

Figure 8: Fractions of metal complexed with glyphosate as a function of pH, for copper and manganese. Figure adapted from Lundager Madsen *et al*[170]

MN AND INFERTILITY

Multiple papers on rodent studies have indicated disruption of the male reproductive system by glyphosate. Acute treatment of 60-day-old male Sprague-Dawley rats to Roundup® caused a marked increase in aromatase mRNA in testicular tissue,[56] likely reflecting an increase in production due to suppression of the activity of aromatase (CYP 19), accompanied by abnormal sperm morphology. Aromatase participates in both hormone synthesis and metabolism. It is an important enzyme in testes that converts testosterone to estrogen, thus regulating the balance of sex hormones.

In vitro studies on Sertoli cells from mouse testis demonstrated that glyphosate opens L-type voltage-dependent calcium channels, leading to calcium-overload cell death.[83] However, glyphosate's disruption of the supply of Mn to sperm may be a more important factor leading to infertility, due to immobilization of the sperm. Sperm are critically dependent on Mn for their motility. Mammalian sperm contain a distinctive form of Mn-dependent adenylate cyclase, which first appears during development in seminiferous tubules simultaneously with the appearance of spermatid cells.[39] It is expressed at the highest levels following sexual maturity. Adenylate cyclase catalyzes the synthesis of cAMP. Bacteria such as *E. coli* and *Salmonella typhimurium* depend on cAMP for flagella formation, and therefore for motility.[318] cAMP-dependent phosphorylation has been linked to activation of motility in sperm flagella from sea squirts[209] and from dogs.[287] Human sperm also depend on cAMP for increased flagellar motility.[210,303] A study on zebrafish demonstrated that glyphosate exposure at concentrations of 5 and 10 mg/L over a 24-h time period reduced sperm motility.[170] Mn stimulated the progressive motility of human sperm in a time- and dose-dependent manner, and this was linked to adenyl cyclase activity.[178] The decrease in male fertility levels today in the industrialized world[111] may therefore be explained by Mn deficiency.

EVIDENCE OF EXPOSURE

Glyphosate-containing herbicides are applied to crops several times each season both for killing weeds and for desiccation just prior to the harvest in non-Roundup®-Ready crops, such as wheat and sugar cane. It accumulates in the leaves, grains, and fruit, and thus cannot be removed by washing and, furthermore, is not broken down by cooking.[41] Nowell *et al*.[206] identified pesticides as a leading cause for declines and deformities among amphibians and pollinators in the United States. A total of 100% of all water surfaces and 96% of all examined fish contained detectable levels of pesticides. In a recent US-based study by Battaglin *et al*.,[22] glyphosate and AMPA were detected frequently in soils and sediment, ditches and drains, rainwater, rivers, and streams.

A recently published study by Shehata *et al*.[264] showed that glyphosate residues can be found in the organs and muscles of chickens that consume glyphosate in their feed, including the liver, spleen, lung, intestine, heart, and kidney. All animals fed a diet contaminated by glyphosate would be subject to such bioaccumulation due to the molecule's ability to act as an attaching ligand. Feed supplementation with humic acid was able to significantly reduce the glyphosate burden in tissues.

A recent paper by Nevison[202] investigated temporal trends in autism since 1988 to assess to what degree the recent observed rate increases are due to increased diagnosis versus increased incidence. She concluded that increased incidence accounts for 75–80% of the tracked increase. She also investigated trend lines for a variety of environmental toxicants potentially implicated in autism. She wrote in the abstract: "Among the suspected toxins surveyed, polybrominated diphenyl ethers, aluminum adjuvants, and the herbicide glyphosate have increasing trends that correlate positively to the rise in autism." As we have stated earlier, glyphosate and aluminum are synergistically toxic.

There has been very little testing of glyphosate levels in either humans or other mammals. Glyphosate is passed in both the urine and the feces. Recent research from Europe has shown that glyphosate is consistently present in significant amounts in the urine of cows consuming Roundup®-Ready feed, as well as in the organs and meat of cattle.[153] Furthermore, they also detected glyphosate in the urine of humans, and the generally healthy population had significantly lower levels than the sick population. Those consuming a predominantly organic diet also had a significantly lower glyphosate burden. Another study found detectable levels of glyphosate in lungs, liver, kidney, *brain*, gut wall, and heart of malformed euthanized 1-day-old Danish piglets, and the authors proposed that glyphosate could be the cause of the deformities.[155]

CONCLUSION

Glyphosate is the most widely used herbicide on the planet, in part because of its perceived low toxicity to humans. In this paper, we propose that glyphosate's chelation of Mn, working together with other known effects of glyphosate such as CYP enzyme suppression and depletion of derivatives of the shikimate pathway in microorganisms, may explain the recent increase in incidence of multiple neurological diseases and other pathologies. We have shown that glyphosate's disruption of Mn homeostasis can lead to extreme sensitivity to variations in Mn bioavailability: While Mn deficiency in the blood leads to impairment of several Mn dependent enzymes, in contrast, excess Mn readily accumulates in the liver and in the brainstem due to the liver's impaired ability to export it in the bile acids. This pathology can lead to liver damage and PD. Mn depletion in the gut due to chelation by glyphosate selectively affects Lactobacillus, leading to increased anxiety via the gut–brain access. Both low Lactobacillus levels in the gut and anxiety syndrome are known features of autism, and Lactobacillus probiotic treatments have been shown to alleviate anxiety. Increased incidence of Salmonella poisoning can also be attributed to glyphosate, through its impairment of bile acid synthesis. Low Mn bioavailability from the blood supply to the brain leads to impaired function of glutamine synthase and a build-up of glutamate and ammonia in the brain, both of which are neurotoxic. Excess brain glutamate and ammonia are associated with many neurological diseases. At the same time, impaired function of Mn-SOD in the mitochondria results in mitochondrial damage, also a hallmark of many neurological diseases. Mn deficiency can account for poor sperm motility and therefore low fertilization rates, as well as poor bone development leading to osteoporosis and osteomalacia. Sea star wasting syndrome and the collapse of coral reefs may in fact be an ecological consequence of the environmental pervasiveness of the herbicide. Many diseases and conditions are currently on the rise in step with glyphosate usage in agriculture, particularly on GM crops of corn and soy. These include autism, AD, PD, anxiety disorder, osteoporosis, inflammatory bowel disease, renal lithiasis, osteomalacia, cholestasis, thyroid dysfunction, and infertility. All of these conditions can be substantially explained by the dysregulation of Mn utilization in the body due to glyphosate.

ACKNOWLEDGMENTS

This work was funded in part by Quanta Computers, Taipei, Taiwan, under the auspices of the Qmulus Project. The authors thank Dr. Nancy Swanson for providing the plots showing correlations over time of multiple diseases and conditions with glyphosate usage on corn and soy in the US.

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Commentary

Glyphosate-based herbicides (GBH) are the major pesticides used worldwide. Initially patented as a metal ion chelator, glyphosate rapidly jumped to a leading position as an active ingredient of commercial pesticides from the 1970s when Monsanto discovered its herbicidal activities. The herbicidal mode of action of glyphosate is primarily to inhibit the shikimic acid pathway,[2] causing a shortage of aromatic amino acids. Since this biochemical pathway does not exist in vertebrates, it is generally assumed that glyphosate is safe for mammals, including humans.[8] As a consequence, GBH are used in private gardens, city parks and along roads and railway lines, as well as within an agricultural context on food and feed crops. All these diverse applications of GBH have resulted in escalating levels of human exposure and thus body burden.

Glyphosate is an aminophosphonic analog of glycine. The fact that glycine and other amino acids like glutamate function as neurotransmitters and play a crucial role in brain function, makes the potential neurotoxic effects of glyphosate a matter of concern.[5] The potential of glyphosate to act as a neurotoxin is further supported by its structural similarity to the glutamate receptor agonist 2-amino-3-phosphonopropionic acid. Indeed, GBH exposure induces glutamate excitotoxicity through L-VDCC and NMDA receptor activation in immature rat hippocampus, by reducing glutamate uptake and metabolism within glial cells, and by increasing glutamate release in the synaptic cleft.[3] However, the lack of esterase inhibition by glyphosate (the neurotoxic mechanism of most organophosphate compounds), was considered by regulatory authorities as sufficient grounds to avoid having to undertake a complete assessment of glyphosate's neurological effects.[6]

The most recent reevaluation of the acceptable daily intake (ADI) for glyphosate within the European Union (EU) conducted by the German regulatory agency (BfR), states that this has been determined by scrutiny of approximately 450 regulatory toxicological studies and 900 publications from the scientific literature.[4] Based on the review of all these investigations, the BfR concluded that the "no observed

adverse effect level" of glyphosate was in the region of 30–50 mg/kg body weight (bw) per day in rats and the ADI was thus calculated at 0.5 mg/kg bw/day, which constitutes a recommended increase from the current 0.3 mg/kg bw/day. However, these glyphosate ADI values have previously been challenged as review of the same studies and especially extending to feeding studies in animals other than rats, suggested that the current ADI of 0.3 mg/kg bw/day was at least three times higher than what the data suggest should be the case.[1] Nevertheless, with a review of such a relatively large number of studies by the official regulatory authorities, the assessment of the toxicological effects of glyphosate is being considered as complete. The notional strength of glyphosate's safety profile has also resulted in it being neglected in some national wide-scale toxicity testing schemes such as the U.S. Environmental Protection Agency (EPA) ToxCast program.

However, a debate continues as to the soundness of this BfR-led assessment as the studies taken into account were performed with an experimental design adapted to the study of poisoning effects based on the principle of "the dose makes the poison"; that is, the higher the dose the greater the poisoning effect. Of major concern is that none of the studies referred to incorporated testing principles derived from a contemporary understanding of (neuro) endocrinology or developmental epigenetics.

In the classic theory of toxicology, as applied for the study of glyphosate toxicity at a regulatory level, a nontoxic threshold is evidenced by decreasing the level of exposure and assuming that toxic effects observed are a linear response to the dose. Lower doses corresponding to environmental exposures are assumed to be safe and are not tested. However, in contrast to a classical poison, an endocrine disruptive chemical (EDC) will alter the functioning of hormonal systems and induce adverse effects at various dosage levels. Such EDC effects will, in some cases, occur in a nonlinear (non-monotonic) manner at environmentally relevant levels of exposure and will not be observed at higher doses. In addition and not surprisingly, EDC effects can be sex-specific in nature. Such nonmonotonic and sex-specific EDC effects have been extensively described for common pollutants.[7] Although nonmonotonic and sex-specific effects have been reported in many cases with GBH, the regulatory authorities considered these as false positive outcomes rather than a suggestion of potential EDC effects.[4]

Major endpoints of toxicity such as neurodevelopmental, reproductive, and transgenerational effects in humans still needs to be investigated at the glyphosate ADI and other concentrations reflective of human levels of exposure. Given its increasing wide-scale use and consequent rise in exposure, we urgently call for greater research efforts on the toxicology of glyphosate and its commercial herbicide formulations, as well as pesticide neurodevelopmental effects in general. Furthermore, pesticide combinatorial (additive or synergistic) effects remain a poorly investigated subject and area of concern that needs to be addressed. Such studies are particularly relevant to the brain since it is physiologically dependent on neurosteroids, making it potentially very sensitive to endocrine disruptive compounds.

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Poultry, Fisheries & Wildlife Sciences

Hoy et al., Poult Fish Wildl Sci 2015, 3:1
http://dx.doi.org/10.4172/2375-446X.1000132

Research Article Open Access

The High Cost of Pesticides: Human and Animal Diseases

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Abstract

A significant degradation in the health of wild animals in Montana has been recorded over the past two decades. We surmise that the health issues are related to pesticide exposure. We present some of the evidence of the deterioration of the health in wildlife, which we used to inspire investigations on human health in the US population. While the animals' exposure is through food, water and air, we believe that human exposure is predominantly through food, as the majority of the population does not reside near agricultural fields and forests.

We have obtained US government data on pesticide usage and on human disease patterns over time from the 1998-2010 hospital discharge data. Since glyphosate is by far the most widely used herbicide, we believe it to be a major source of contamination for humans. Correlations between glyphosate usage and specific health issues, along with the known toxicology profile of glyphosate obtained from the literature, reflect a plausible causal relationship.

Because much of the wildlife data is from deer fawns, most of the human data presented here involve newborn infants, but we also present some data for children 0-15 years old and for the full population (except newborn). We found many diseases and conditions whose hospital discharge rates match remarkably well with the rate of glyphosate usage on corn, soy, and wheat crops. These include head and face anomalies (R=0.95), newborn eye disorders, newborn blood disorders (R=0.92), newborn skin disorders (R=0.96), lymph disorders in children 0-15 (R=0.86) and in the general population except newborn (R=0.89), congenital heart conditions in newborns (R= 0.98), enlarged right ventricle in all age groups except newborn (R=0.96), newborn lung problems (R=0.95), pulmonary bleeding and edema for all age groups except newborn (R=0.97), liver cancer for all age groups except newborn (R=0.93), newborn metabolic disorders (R=0.95) and newborn genitourinary disorders (R=0.96).

Keywords: Glyphosate; Brachygnathia; Hypothyroidism; Congenital heart defects; Thymus; Lymphedema; Hepatic carcinoma; Hypospadias; Genitourinary disorders

Introduction

One of the promises assured with genetically engineered (GE) herbicide-resistant crops was that they would require many fewer pesticides, providing a more sustainable agricultural option. Several GE crops, including cotton, canola, corn, soy, sugar beets and alfalfa, are engineered to withstand direct application of glyphosate, the active ingredient in the pervasive herbicide, Roundup. As a result of the widespread acceptance of GE crops, the increasing practice of using glyphosate for pre-harvest dry-down in grains and legumes, along with the emergence of glyphosate-resistant weeds, the use of glyphosate has skyrocketed since 1996 [1-3].

With the exception of glyphosate, pesticide use on crops was indeed reduced for the first 5 or 6 years after the introduction of these GE crops. Then something happened after about 2002, resulting in a steep increase in glyphosate and 2,4-D applications on corn, soy and potato, along with an increase in dicamba on wheat. This coincides with a steep increase in the number of confirmed cases of glyphosate-resistant weeds [1] as shown in Figure 1.

The active ingredient in the pesticides is usually an acid. To make the pesticides more water soluble and therefore easier to package and distribute, they are chemically altered into a salt or ester formulation. Various salt formulations include isopropylamine, diammonium, monoammonium, or potassium as the cation. Adjuvants are increasingly added to enhance the efficacy of the herbicides, particularly with the advent of the glyphosate-resistant weeds. One adjuvant is oxalic acid or an oxalate salt (potassium oxalate, e.g.) added to the stable salt formulations. For example, a 2006 patent by Xu et al. [4] discloses pesticide compositions, especially storage-stable herbicidal concentrates, containing oxalic acid and glyphosate that allegedly exhibit enhanced efficacy due to the addition of oxalic

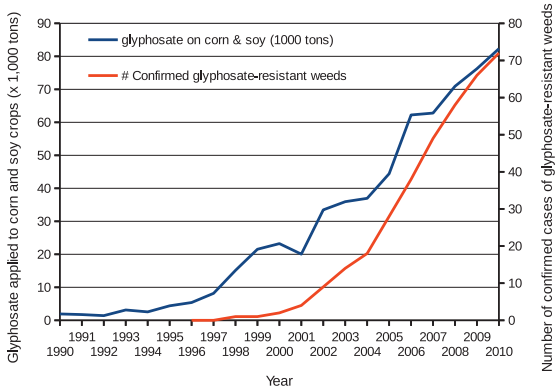

Figure 1: Glyphosate applications to corn, soy and cotton along with the advent of glyphosate-resistant weeds.

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Received April 16, 2015; **Accepted** May 04, 2015; **Published** May 30, 2015

Citation: Hoy J, Swanson N, Seneff S (2015) The High Cost of Pesticides: Human and Animal Diseases. Poult Fish Wildl Sci 3: 132. doi:10.4172/2375-446X.1000132

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2,4-D (2,4-Dichlorophenoxyacetic acid)		**Year first applied to crop**				
Formulation	**Trade names**	**Corn**	**Soy**	**Potato**	**Winter wheat**	**Spring wheat**
2,4-D sodium salt	2,4-DB, Butoxone®	--	1990	--	--	--
2,4-D isopropylamine salt	Campaign® (2,4-D + glyphosate iso. salt)	2005	--	--	2006	2006
2,4-D tri-isopropanolamine salt	Tordon® (2,4-D + picloram) Banvine® (2,4-D + dicamba)	--	--	--	--	2006
2,4-D dimethylamine salt	Saber®, 2,4-D Amine, Savage®, Weedar® 64	2003	2004	2005	2004	2004
2,4-D 2-ethylhexyl ester	Solve®, Barrage®, Salvo®, Maestro® D, Outlaw®	2005	2005	2005	2006	2006
2,4-D butoxyethyl ester	2,4-D BEE, Agri Star® D-638, Weedone® LV6	2005	2005	--	--	--
Dicamba (3,6-dichloro-2-methoxybenzoate)		**Year first applied to crop**				
Formulation	Trade names	Corn	Soy	Potato	Winter wheat	Spring wheat
Dicamba dymethylamine salt	Diablo®, Banvel® 720, Oracle®, Rifle®, Distinct®, Sterling®, Weedmaster®	1999	--	--	2006	2006
Dicamba diglycolamine salt	Clarity®, Vanquish®	2005	2005	--	2006	2006
Dicamba sodium salt	Status®, Distinct®, Celebrity®, Overdrive®, Yukon®	2001	--	--	2006	2004
Dicamba potassium salt	Marksman® (also contains Atrazine)	1998	--	--	--	--
Glyphosate (N-(phosphonomethyl) glycine)		**Year first applied to crop**				
Formulation	Trade names	Corn	Soy	Potato	Winter wheat	Spring wheat
Glyphosate dimethylamine salt	Roundup®, Rodeo®, Durango DMA®, Duramax®	2003	2002	--	2012	--
Glyphosate isopropylamine salt	Roundup®Ultra, Honcho®, Roundup®Pro, Ranger Pro®, Roundup®Custom, Mad Dog Glyphosate®	2005	2005	2005	2006	2006
Glyphosate potassium salt	Roundup®WeatherMax Roundup®PowerMax Touchdown®, RT Master® II	2010	2012	--	2009	2012

Table 1: Salt and Ester Formulations of Pesticides.

acid. The hypothesis presented for its effect is that it increases cell membrane permeability, suppresses oxidative burst, or increases expression of hydroxyproline-rich glycoproteins. However, it is also likely that it inhibits the breakdown of glyphosate, since oxalate inhibits the breakdown of glyoxylate, which is a disintegration product of glyphosate [5]. This would lead to an accumulation of glyoxylate, a strong glycating agent that would damage membrane fatty acids, explaining the increase in membrane permeability [6]. This patent also discloses that a variety of surfactants, including amines, amine oxides and quaternary ammonium compounds, can be used in combination with oxalic acid for pesticide compositions.

Manufacturers of pesticides do not disclose the adjuvants and surfactants used in any of their products, claiming that they are trade secrets. Only the formulation of the active ingredient can be traced. Table 1 shows the various formulations for 2,4-D, dicamba and glyphosate and when they first appeared in the USDA survey data. When they initially appeared, salts were a small percentage of the total amount of pesticides applied, but within a couple of years (by 2006) nearly all of the applications for a given herbicide were salt formulations. In the pesticide data shown in Figures 2-7, arrows have been superimposed on the graphs indicating when salts were first used and again when nearly all of the formulations used were salts.

One of us (Hoy) has been documenting congenital malformations in Montana wildlife for the past 19 years. In this paper, we present documentation of wildlife deformities and evidence of organ damage. In addition, we obtained corresponding data for human congenital malformations and diseases in newborn infants, along with diseases in children 0-15, and all age groups (except newborn) from the US hospital discharge data. Finally, we obtained pesticide application data on selected crops from the USDA. We show that congenital malformations and wildlife diseases follow the trends for dicamba, 2,4-D, chlorothalonil and glyphosate use. We also show that congenital malformations and other diseases in humans follow the trends in glyphosate use. We hypothesize that the primary exposure route for humans is through food, whereas the primary exposure for animals is not only food but also direct exposure through air and water. Some of these conditions show a steep increase at the same time that the switch to the salt formulations of the herbicides was made.

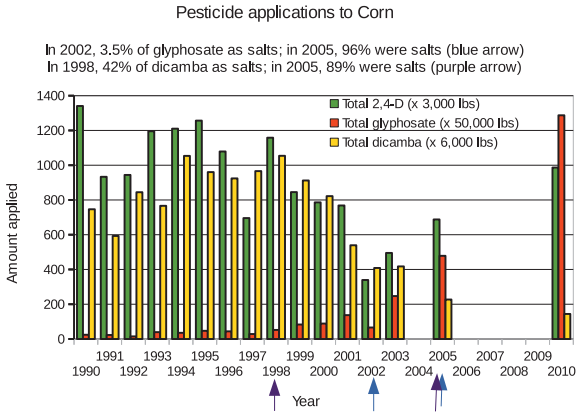

Figure 2: Herbicide applications to corn. Scale varies for each as indicated in the legend. Glyphosate salts were first applied in 2002, almost exclusively applied by 2005. Dicamba salts were first applied in 1998, almost exclusively by 2005. EPTC and alachlor applications have steadily decreased, becoming negligible by 2002 (not shown). Atrazine applications to corn crops have remained approximately constant at about 52.5 million pounds (also not shown).

Data Collection Methods

Pesticides

The United States Department of Agriculture National Agricultural

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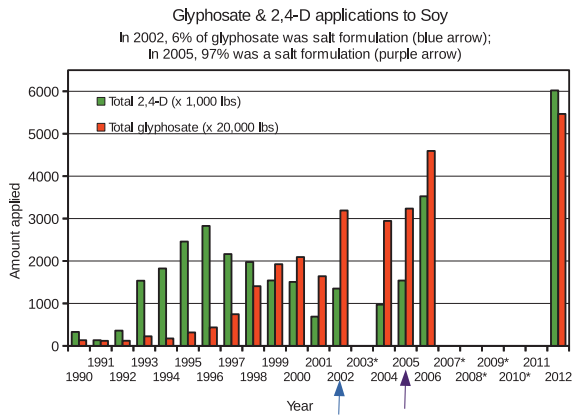

Figure 3: Glyphosate and 2,4-D applications to soy. Scale varies for each as indicated in the legend. Glyphosate salt formulations began to be applied to soy in 2002, almost exclusively by 2005.

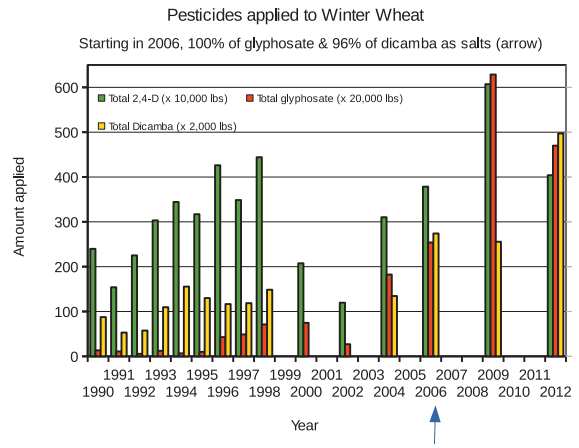

Figure 4: Glyphosate, dicamba and 2,4-D applications to winter wheat. By 2006, nearly all of the glyphosate and dicamba were salt formulations. Scale varies for each as indicated in the legend.

Statistics Service (USDA:NASS) maintains a database of US crops. Every year they randomly select fields of certain crops and send surveys to the persons who manage those fields. Among other things, they ask what herbicides were used, the application rate and how many times was it applied. Surveys are only sent to the states that are the major producers of a given crop, usually accounting for about 90% of the total US acreage planted in that crop. They then perform a statistical analysis and report the total acreage planted, the Percentage of Acres Treated (PAT) with each herbicide for that crop and the application rate per acre per year. One can then calculate the total amount of an herbicide that was applied to that crop in the survey states for that year.

Data files containing the information for pesticide applications are available from 1990-2012 [7]. We extracted the data for glyphosate, 2-4,D, dicamba, chlorothalonil, ETPC (S-Ethyl Dipropylthiocarbamate), atrazine and alachlor applications to corn, soy, potato and wheat crops. Sampling errors for the pesticide application data were less than 5% for most of the pesticides over most of the time period examined. Sampling errors (reported as standard errors) are small (<5%) in both the PAT and the application rate if the PAT is greater than 50%. Sampling errors are 5-10% if the PAT is between 10-50%, while the sampling errors are 10-100% if the PAT is <10%. The PAT for chlorothalonil on potato has exceeded 50% since 1994. The PAT for glyphosate on soy has exceeded 50% since 1998. The PAT for glyphosate on corn has exceeded 50% since 2006. The PAT for 2,4-D on spring wheat exceeds 50% over the entire data range. The PAT for dicamba ranges between 20% and 55% for spring wheat. By 2006, the PAT for glyphosate on spring wheat was 31%, durum wheat was 48% and winter wheat was 15%. Details on the PAT with glyphosate on corn and soy can be found in [3].

Wildlife

Wild ruminates were the primary animals studied. The study area where white-tailed deer (*Odocoileus virginianus*) were examined is Ravalli County, in the far western portion of Montana. The north flowing Bitterroot River forms the Bitterroot Valley (BV) located

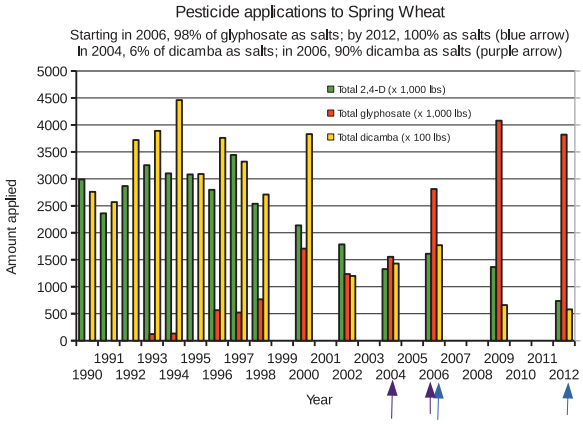

Figure 5: Glyphosate, dicamba and 2,4-D applications to spring wheat (except durum). By 2006, nearly all of the glyphosate and dicamba were salt formulations. Scale varies for each as indicated in the legend.

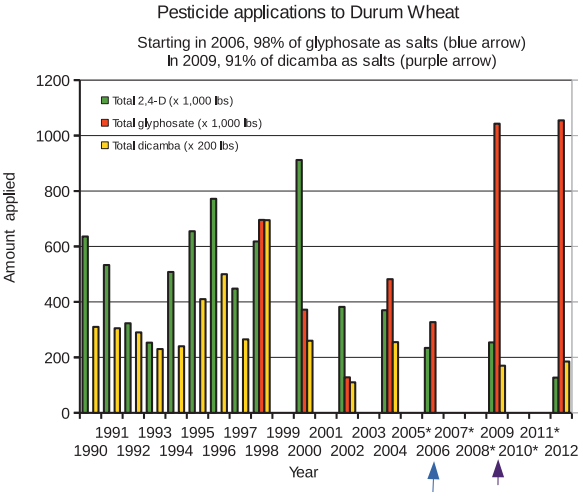

Figure 6: Glyphosate, dicamba and 2,4-D applications to durum wheat. By 2005, nearly all of the glyphosate and dicamba were salt formulations. Scale varies for each as indicated in the legend.

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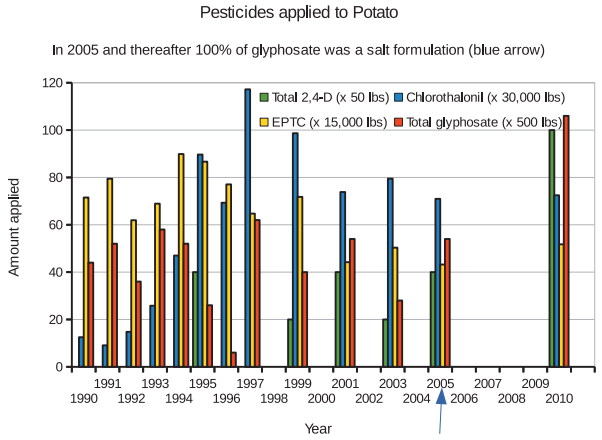

Figure 7: Pesticides applied to potato crops. By 2005, all of the glyphosate was a salt formulation. Scale varies for each as indicated in the legend.

between the Bitterroot Mountains on the west and the Sapphire Range on the east. Riparian vegetation along the river and its tributaries provide cover close to feeding areas in fields for herds of white-tailed deer.

There are two major highways running north and south through the valley on each side of the Bitterroot River, with a network of secondary roads throughout the BV. With the exception of hunting, encounters with vehicles, fences and dogs account for the majority of RC white-tailed deer mortalities.

White-tailed deer that were accident-killed or had been euthanized due to injuries were examined post-mortem from 1995 through 2014. Age, sex, date of examination and several body measurements, including measurement of the mouth and bite and the size of the male sex organs on the external skin were recorded for each animal. In addition, the condition of the heart (normal or enlarged right ventricle) and the lungs (degrees of inflammation symptoms) were recorded. On necropsied newborns, the condition of the thymus was also documented. The year of birth of each white-tailed deer was determined by examining the tooth eruption as outlined by Mosby [8]. Additionally, the following were examined and observations recorded: the conjunctiva of the eyes for blepharitis, the teeth, limbs and hooves for abnormalities.

In addition to white-tailed deer carcasses, heads from hunter-killed white-tailed deer, elk (*Cervis canadensis*), mule deer (*Odocoileus hemionus*), bighorn sheep (*Ovis canadensis*), moose (Alces alces) and pronghorn antelope (*Antilocapra americana*) were examined from animals harvested throughout Montana and surrounding states. Domestic ruminants examined for jaw malocclusions included newborn domestic goats (*Capra aegagrus hircus*) in 2009 and heads from newborn and butchered domestic beef cattle (*Bos taurus*) between 2007 and 2009. Malformations on other vertebrate species were documented with photographs and date of observation. Birth defects were observed on individuals of multiple bird species and on three individuals of the western toad (*Bufo boreas*). Examples of recent eye malformations and liver tumors on various vertebrates were documented with photos.

To quantify brachygnathia superior (BS, or under bite) and mandibular brachygnathia (MB, or overbite), the distance between the extreme anterior of the maxillary pad and the top edge of the central lower incisors was measured in millimeters on all examined white-tailed deer fawns each year from spring of 1995 through spring of 2014.

The heart and lungs were examined on all necropsied deer, both adults and fawns. The severity of the enlargement of the right ventricle of the heart on each deer was designated with a number beginning with 0 for hearts with no enlargement (normal) to 3 for a severely enlarged right ventricle. Similarly, the inflammation of the lungs was recorded with 0 being normal, and 1 through 3 designating the severity of inflammation, and 4 to designate that the animal had died of a hemorrhage in the lungs.

To quantify the genital hypoplasia on male fawns, a measurement from the body wall to the tip of the penis sheath and a measurement of the scrotum from the body wall to the lowest point on the scrotum were taken. To document the misalignment of the hemiscrota, the length from anterior to posterior and the width from side to side of the scrotum were measured. The length of the testes was measured for comparison with the hemiscrota length. Whether the testes were in the hemiscrota or partly or completely ectopic was recorded.

In addition, a study of genital hypoplasia and shortened urogenital distance in male eastern fox squirrel (*Sciurus niger*) populations in Northern Ravalli County, MT is currently in progress. There appear to be significant numbers of similar reproductive defects on examined males of several other Western Montana rodent species, including deer mouse (Peromyscus manipulates), house mouse (*Mus musculus*), red squirrel (*Tamiasciurus hudsonicus*), northern flying squirrel (*Glaucomys sabrinus*), yellow pine chipmunk (*Eutamias dorsalis*) and yellow-bellied marmot (*Marmota flaviventris*).

Humans

Hospital discharge data, containing diagnoses collected from hundreds of hospitals by the United States Centers for Disease Control and Prevention (CDC) can give a snapshot of disease trends over time. These data are available for free download from the Web. Raw data files were available from 1998 through 2010. We downloaded the files and documentation from the CDC website. Each data file contains thousands of discharge records collected from hospitals using a statistically random sampling procedure [9]. The records contain information about the age, sex, race, geographic location and diagnoses for each discharge. The diagnoses are recorded by the International Classification of Diseases, Ninth Revision (ICD-9) codes. Up to seven diagnostic codes can be recorded for each discharge, with the first listed being the primary reason for hospital admission. We included in the set for any particular ICD-9 code any event which mentioned that code as one of the diagnostic codes for the event; i.e., we did not treat the first-mentioned code in any special way.

A computer program was written to query the data file for specific ICD codes for each year. We were interested in disease trends for three distinct age groups: (1) infants (<6 days old), (2) children (6 days–15 years old), and (3) all ages except infant (6 days–100 years old). A rate of increase, as an estimate of prevalence, over time for each particular diagnosis was obtained as follows:

$$\hat{a} = a * T / (t * P)$$

where â is the normalized hospital discharge rate for a disease in a year; a is the total number of the hospital discharge records of the disease in the year computed from the raw files; T represents the total number of hospital discharges in that year in the US; t is the total number of

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hospital discharge records in the sampled hospitals in that same year, which is computed from the raw files; and P is the total population in the US for that year. Population estimates were obtained from the CDC. For the newborn data, we assumed that T/P = 1, i.e. the number of hospital discharges for newborns was equal to the population of newborns.

Using the information in the CDC documentation, we calculated some of the standard errors in these data. The standard errors for the general population were all less than 10%. The largest standard errors were for the acquired hypothyroidism in children, which ranged between 22%-37%. Standard errors for newborns could not be calculated because they were not included in the CDC tables.

Results

US trends in pesticide usage

With the exception of glyphosate, pesticide use on crops decreased for the first 5 or 6 years after the introduction of GE crops in 1996. Survey data from the US Department of Agriculture [7] show that the use of 2,4-D and dicamba on corn steadily decreased starting about 1996 as shown in Figure 2. Applications of EPTC and Alachlor also decreased, but the use of Atrazine has remained constant. The use of 2,4-D on soy also started decreasing in 1996 as shown in Figure 3. In the meantime, glyphosate was being promoted as a pre-harvest treatment to grain, dried pea and bean, and potato crops for more even ripening, dry-down and pre-harvest weed control [10]. The use of 2,4-D and dicamba on wheat decreased, being replaced by glyphosate starting in early to mid 1990s (Figures 4-6). With the exception of fungicides used for potato blight, pesticide applications to potatoes were also decreasing (Figure 7).

After about 2002, there was a steep increase in glyphosate and 2,4-D applications on all of these crops, along with an increase in dicamba on wheat. This coincides with a steep increase in the number of confirmed cases of glyphosate-resistant weeds as shown in Figure 1.

As seen in the Figures, not all crop data were reported for all years. Data for glyphosate applications to corn, soy and wheat were interpolated as outlined in [3] and the results are shown in Figure 8.

Pesticide use in the region of interest

Prior to 1994, there was extensive use of multiple herbicides and other pesticides, especially 2,4-D and dicamba, on wheat, potato and other crops in Idaho, Washington, Oregon and other states upwind of Western Montana as shown in Figures 7 and 8. Glyphosate was also being used prior to 1994, and its use has increased significantly since 1996. The formulation for glyphosate and other commonly used herbicides applied during the growing seasons in 2006 and 2007 and since was changed to salt formulations [4] (we hypothesize that oxalic acid was introduced with these salts as an adjuvant, but this can not be confirmed).

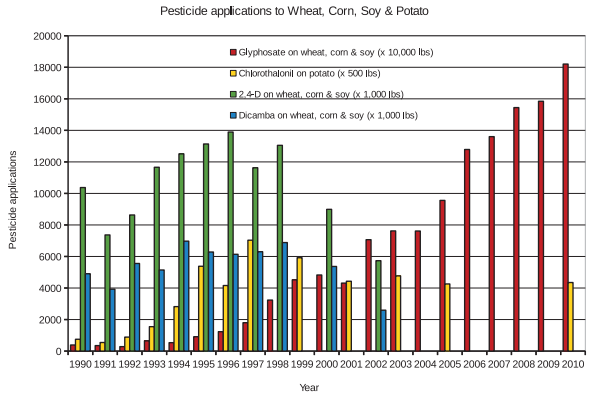

Figure 8: Total glyphosate, 2,4-D and dicamba applied to wheat, corn and soy crops; chlorothalonil applied to potato crops. Glyphosate data has been interpolated. Data for dicamba and 2,4-D were not added in the years when data were not reported.

In addition to glyphosate, 2,4-D and Dicamba as shown in Figure 8, other pesticides were widely used in Western United States prior to 1994, including picloram, atrazine and several organochlorine herbicides. Multiple fungicides were used on over 500,000 acres of potato fields in Idaho, Washington and Oregon. Many types of insecticides were also used in Western Montana and states upwind long before 1994. Even with this extensive exposure to multiple wind drift and locally applied pesticides, almost no birth defects were observed or reported on developing young in Western Montana until 1995. An epidemic of multiple birth defects began being observed on many individuals of domestic and wild animals born that spring [10,11], with a significant increase in many of the birth defects over the study period, despite substantial annual variability.

Development and health issues in wild animals and humans

In the case of the ungulates, we tabulated frequencies of multiple developmental defects as discussed in the Methods section, and noted a general pattern consisting of a high rate of disease early in the study period, a gradual decline until around 2006 and then a generally rising trend subsequently. This is consistent with the trends in pesticide use shown in Figures 2-8. We hypothesize that chlorothalonil on potatoes, along with dicamba and 2,4-D on the other crops, may contribute significantly to the early disease patterns in wildlife, whereas glyphosate is a major factor in the later rise in observed frequency.

We sought human data on disease trends in the hospital discharge data that would correspond as much as possible with the observed defects in the wild animals. This was not always easy, as jaw malocclusion is not reported explicitly in the database, nor is genital malformations. However, there are several malformations of the lower face that are tracked, such as dent facial anomalies (ICD 526), diseases of the jaws (ICD 527), diseases of the salivary glands (ICD 527) and diseases of the oral soft tissues (ICD 528), whose trends can be compared with those observed in the animals with jaw malformations. The plot we obtained for human urogenital disorders encompasses hydrocele (watery fluid around one or both testicles, ICD 778.6); hypospadias (ICD 752.6); and hydronephrosis -- obstruction of urine flow (ICD 591), and other disorders of the kidney and ureter (ICD 593). Thyme involution and dysfunction, notable in postmortem examination of the wild animals, is not normally indicated in ICD-9. Although a code exists for diseases of the thymus (254.8), it is almost never used (only 2 cases among the infant and newborn data in our data set). However, T-lymphocytes mature within the thymus gland, so its impairment can be reasonably linked to immune system disorders. In most other cases, such as the organ tumors, eye deformities, skin disorders, liver cancer and metabolic issues documented on wild and domestic animals, a more direct comparison was possible.

Our results are illustrated in Figures 9-32, and are discussed below in more detail. In addition to plots where we superimpose time trends for human data or wild animal data with pesticide usage, we also provide photos taken of a variety of wild and domestic animals

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Figure 9: Brachygnathia superior and wide lower incisors on ruminant species. A. White-tailed deer fawn skull. B. Mule deer fawn skull. C. Elk calf skull. D. Adult male bighorn sheep skull, showing short narrow premaxillary bone. E. Domestic beef calf skull. F. Skull of an adult male domestic goat.

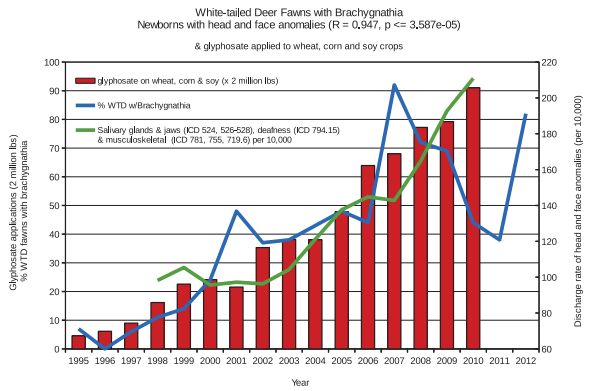

Figure 10: Comparison of hospital discharge rates for congenital facial anomalies with glyphosate applications. The graph shows the percentage of white-tailed deer fawns with brachygnathia superior from 1995-2012; congential facial and musculoskeletal anomalies; and glyphosate applications to wheat, corn and soy crops. The Pearson correlation coefficient between the newborn anomalies and glyphosate applications is R = 0.947.

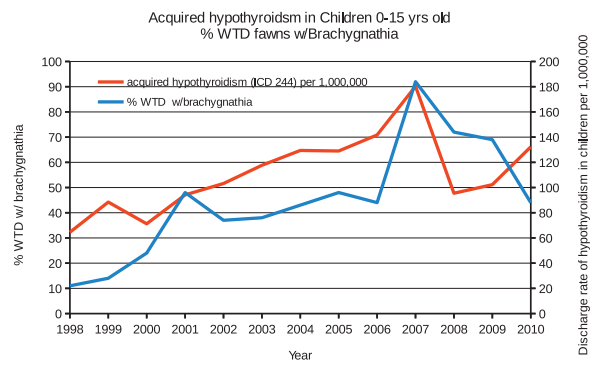

Figure 11: Hospital discharge rates for hypothyroidism in children superimposed with the percentage of WTD with brachygnathia superior.

exhibiting pathologies (Figures 9, 12, 14, 16, 18, 20, 24, 26 and 27).

Congenital head and facial malformations

Brachygnathia superior (BS), the underdevelopment of the upper facial bones of ungulate species, has been photographed in countries around the world and posted on the Internet, usually labeled as under bite. In Montana and throughout the United States, wild and domestic ungulate species appear to have an extremely high prevalence of BS, including our main study species, white-tailed deer [11] as shown in the photos in Figure 9. The percentage of white-tailed deer with BS has increased significantly in this region since 1995, as shown in Figure 10. Figure 10 also shows the prevalence of head, face and musculoskeletal anomalies in newborn infants superimposed with glyphosate applications to wheat, corn and soy crops. The newborn data correlate with glyphosate usage with a Pearson correlation coefficient of R=0.947.

We also noticed that trends in hypothyroidism in children aged 0-15 were rising, and that these patterns aligned very well with the data on brachygnathia in wild animals, both exhibiting a sharp peak in 2007 (Figure 11) approximately coincident with the changeover to salt formulations in the herbicides. Congenital hypothyroidism is common, and it is linked to other congenital disorders, for example hearing loss [12] and renal and urinary tract disorders [13]. According to Kumar, et al. [13], "Congenital hypothyroidism is the most common congenital endocrine disorder, affecting 1 in 3000 to 4000 newborns. Its incidence has increased 138% from 1978 to 2005 in New York State and 73% in the US from 1987 to 2002."

Disorders of the eyes

Figures 12 and 13 depict eye disorders in wild animals and humans respectively. Figure 12 illustrates several cases of various eye deformities in black-billed magpies (*Pica hudsonia*), great horned owls (*Bubo virginianus*), a western toad (*Bufo boreas*), a pygmy goat, and severe blepharitis on a white-tailed deer fawn that were documented by Hoy.

Figure 13 shows the time trends of congenital disorders of the eye

Figure 12: Recent eye malformations in vertebrates. A. Black-billed Magpie fledgling showing a normal-sized eye. B. Blind Black-billed Magpie fledgling right eye, both eyes were underdeveloped. C. Adult 2014 western toad with right eye not formed and left eye normal. D. Pygmy goat born in 2015 with small eye, malformed external ear and BS. E. The normal left eye and eyelids of a Great Horned Owl (GHOW). F. Underdeveloped left eye with malformed eyelids and pupil on 2014 hatch year GHOW. G. Face of a 2013 fledgling GHOW showing the malformed left pupil and malformed eyelids on both eyes. H. The malformed left pupil and eyelids of another 2014 hatch year GHOW. I. The inflamed conjunctiva of a female WTD fawn after exposure to environmental toxins.

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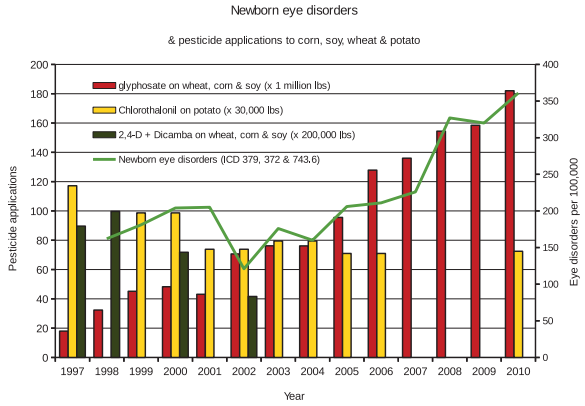

Figure 13: Hospital discharge rate for congenital eye disorders superimposed with pesticide applications to wheat, corn and soy crops. Eye disorders include: congenital anomalies of eyelids lacrimal system and orbit (ICD 743.6); disorders of conjunctiva (ICD 372); other disorders of the eye (ICD 379).

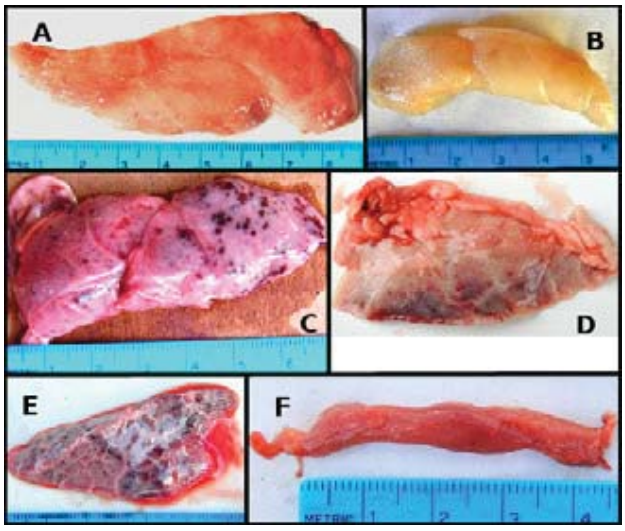

Figure 14: Newborn white-tailed deer thymus conditions. A and B. Normal thymus color and shape. C and D. Thymus with red spots throughout. E. Odd shaped, mostly red thymus. F. Undersized thymus, red throughout.

in newborns, superimposed with pesticide applications to wheat, corn, soy and potato crops. Eye disorders include congenital anomalies of eyelids, lacrimal system and orbit (ICD 743.6), disorders of conjunctiva (ICD 372), and other disorders of the eye (ICD 379). The pattern is somewhat different from that of most other human disease trends we have found, in that it more closely matches some of the time trends for the animal data and the overall pesticide data, not glyphosate alone.

Congenital thymus malformations and impaired immune system

On examined fawns of white-tailed deer, newborn domestic goats and other newborn ruminants, BS and congenital defects of the thymus (Figure 14) increased in spring of 2007 and have remained high since. This is again approximately coincident with the changeover to salt formulations in the herbicides.

There is no data in the hospital discharge records on the thymus. However, since hematopoietic progenitor cells enter the thymus from the blood and then multiply to generate a large population of T-cells, there should be some relationship between thymus impairment and diseases of the blood, especially white blood cells. We combined the following newborn blood disorders: transient neonatal thrombocytopenia (ICD 776.1), cutaneous hemorrhage of fetus or newborn (ICD 772.6), diseases of white blood cells (ICD 288) and nonspecific findings on examination of blood (ICD 790), to form the plot shown in Figure 15. While these conditions are only indirectly related to thymus problems, the trend is well matched to the rise in glyphosate usage on crops (R=0.92; p<8.2E-5). Lymphatic disorders are also rising in the human population, as discussed later in this section.

Newborn skin disorders

In recent years, observation of skin disorders, rash, blistering and

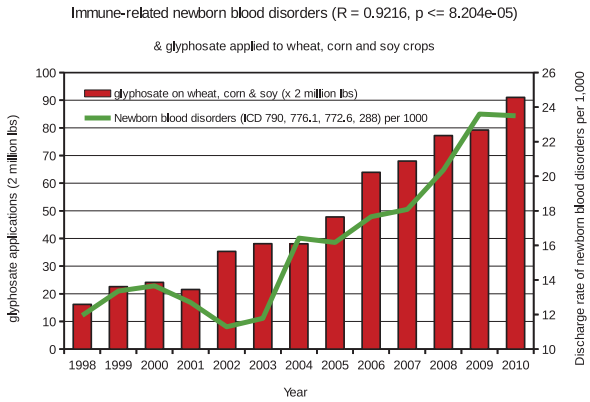

Figure 15: Hospital discharge rates for newborn blood disorders superimposed with glyphosate applications to wheat, corn and soy crops. The blood disorders are: transient neonatal thrombocytopenia (ICD 776.1); cutaneous hemorrhage of fetus or newborn (ICD 772.6); diseases of white blood cells (ICD 288); and nonspecific findings on examination of blood (ICD 790). The Pearson correlation coefficient is R=0.9216.

Figure 16: Skin disorders on wild and domestic mammals. A. Large blisters at the base of the right ear on a male WTD fawn, born 2013. B. Hair loss on shoulders, sides and hind legs of a female WTD fawn after exposure to environmental toxins, born 2003. C. Male WTD fawn inner ear skin with chemical blistering, born 2010. D. Young male eastern fox squirrel's left ear showing severe chemical skin blisters in 2005. E. Adult female dog with chemical blisters, summer 2013. F. Adult female WTD with multiple skin growths in May, 2010.

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skin tumors have been increasing on birds and wild and domestic mammals (Figure 16). We consequently examined data for skin disorders on humans. Figure 17 shows newborn skin disorders and skin disorders for the general population superimposed with glyphosate applications to wheat, corn and soy crops. The newborn skin disorders include: atopic dermatitis (ICD 691); pilonidal cyst (ICD 685); erythema and urticarial (ICD 778.8); vascular hamartomas (benign tumors) (ICD 757.32); pigment anomalies (ICD 757.33); unspecified deformities of hair, skin and nails (ICD 757.9); and meconium staining (ICD 779.84). The Pearson correlation coefficient with glyphosate usage is R=0.963. Skin disorders for the general population include: rash, swelling and changes in skin tone and texture (ICD 782); eczema (ICD 692); and psoriasis (ICD 696). The Pearson correlation coefficient with glyphosate usage is R=0.899.

Lymphatic disorders in the non-newborn populations

The thymus regulates the immune system; therefore, any problems with the thymus will result in a compromised immune system. The human lymphatic disorders, in particular, dramatically increased in 2007 at the same time that almost all of the glyphosate was being used as a salt formulation.

In conjunction with the increase in birth defects after spring of 1995, necropsied wildlife and domestic ruminants of all ages had various degrees of dilation of the lymphatic vessels on the surface of their hearts. The lymphatic vessels on hearts, especially of newborns, were more severely affected beginning in 2007, as illustrated by the last two photos of fawn hearts shown in Figure 18. Data for humans were examined for similar effects on the lymphatic system. The increase in lymphatic disorders among humans is not restricted to the infant population. Figure 19 shows the hospital discharge rate for children aged 0-15 with lymphatic disorders, superimposed with glyphosate applications to wheat, corn and soy crops. The disorders include: lymphedema (ICD 457), lymphocytosis (ICD 288.6), and Castleman's disease (angiofollicular lymph node hyperplasia) (ICD 202). The correlation coefficient is R=0.861. Figure 19 also shows the hospital discharge rate of these same lymphatic disorders over the full age range (except newborn). The correlation coefficient between this and glyphosate applications to wheat, corn, and soy crops is R=0.885.

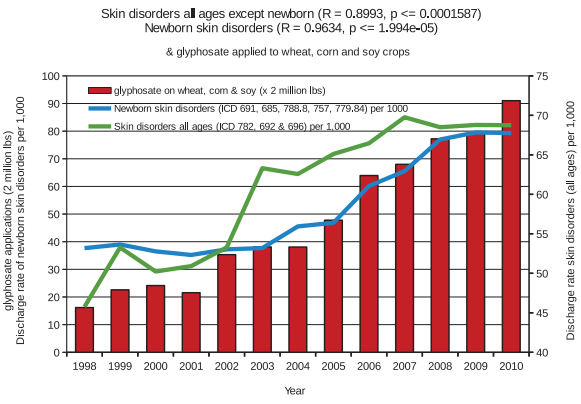

Figure 17: Hospital discharge rates for newborn skin disorders and skin disorders in the general population superimposed with glyphosate applications to wheat, corn and soy crops. The newborn skin disorders are: atopic dermatitis (ICD 691); pilinidal cyst (ICD 685); erythema and urticaria (ICD 778.8); vascular hamartomas (ICD 757.32); pigment anomalies (ICD 757.33); unspecified deformities of hair, skin and nails (ICD 757.9); and meconium staining (ICD 779.84). The Pearson correlation coefficient is R=0.9634. Skin disorders for the general population include: rash, swelling and changes in skin tone and texture (ICD 782); eczema (ICD 692); and psoriasis (ICD 696). The Pearson correlation coefficient is R=0.8993.

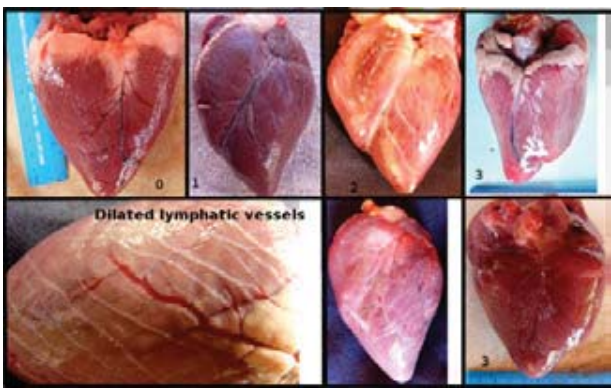

Figure 18: White-tailed deer heart conditions ranked from 0-3. 0. Normal heart. 1. Slightly enlarged right ventricle. 2. Moderately enlarged right ventricle. 3. Severely enlarged right ventricle. Dilated lymphatic vessels on heart surface of newborn fawn and close-up of dilated lymphatic vessels on newborn fawn. Corresponding numbers were used in the field to record the presence or severity of any abnormal heart condition observed.

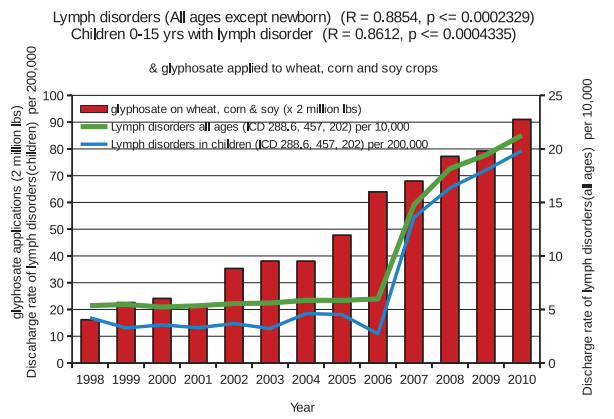

Figure 19: Hospital discharge rates for children with lymphatic disorder and lymphatic disorder in the general population superimposed with glyphosate applications to wheat, corn and soy crops. The lymphatic disorders for children are: lymphedema (ICD 457); Lymphocytosis (ICD 288.6); Castleman's disease (angiofollicular lymph node hyperplasia, ICD 202). The Pearson correlation coefficient is R=0.8612. The lymphatic disorders for the general population are: lymphedema (ICD 457); Lymphocytosis (ICD 288.6); Castleman's disease (angiofollicular lymph node hyperplasia, ICD 202). The Pearson correlation coefficient is R=0.8854.

Diseases and malformations of the heart and lung

On necropsied deer of all ages, the prevalence and severity of enlarged right heart ventricle (Figure 18) and emphysema-like symptoms on lungs (Figure 20) were high in 1998 and 1999, and then decreased until 2005, when these unusual conditions of the heart and lung increased dramatically, as shown graphically in Figure 21. Again, the increase after 2005 is approximately coincident with the switch-over to salt formulations in the herbicides.

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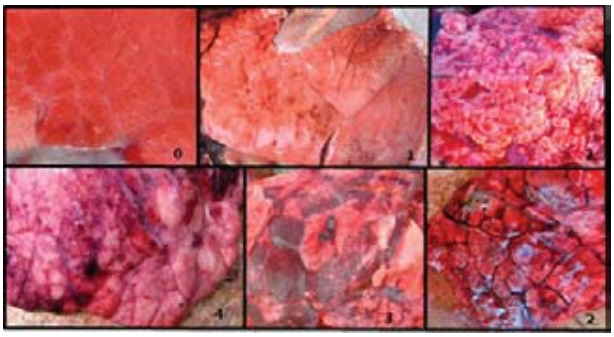

Figure 20: White-tailed deer lung conditions ranked 0-4. 0. Normal lungs. 1. Slightly bumpy on outer lobes . 2. Raised alveoli on much of lung area . 3. Raised alveoli and white areas in lungs. 4. Raised alveoli and bleeding lungs. Corresponding numbers were used in the field to record the presence or severity of any adverse lung conditions observed.

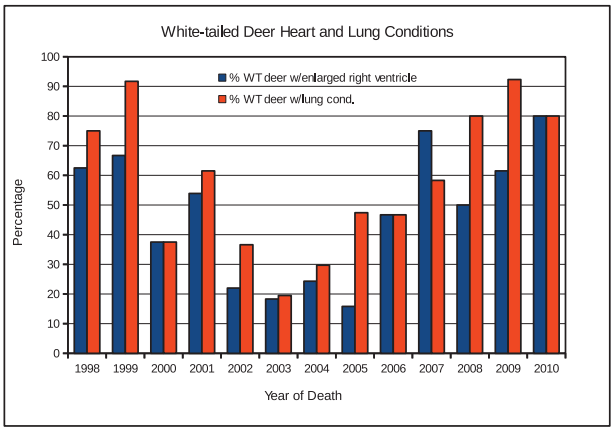

Figure 21: Percentage of white-tailed deer with heart and lung conditions, 1998-2010.

We compared this trend with human data in Figure 22. Both newborn data for congenital heart disorders and data for all ages (except newborn) on enlarged right ventricle show remarkable correspondence with glyphosate usage on core crops. The tabulated newborn heart conditions include: heart murmur (ICD 785.2); ostium secundum type atrial septal defect (ICD 745.5); patent ductus arteriosus (ICD 747.0); pulmonary artery anomalies (ICD 747.3); other congenital anomalies of circulatory system (ICD 747.8); other heart/circulatory conditions originating in the perinatal period (ICD 779.89); and bradycardia (ICD 779.81,427.89). The Pearson correlation coefficient between congenital heart defects and glyphosate applications is R=0.983, and for enlarged right ventricle it is R=0.955.

Figure 23 shows newborn lung conditions superimposed with pulmonary bleeding and edema for all ages (except newborn), and with glyphosate usage on wheat, corn, and soy crops. The newborn lung conditions include: asphyxia and hypoxemia (ICD 799); pulmonary artery anomalies (ICD 747.3); meconium passage during delivery (ICD 763.84); and other respiratory conditions of fetus and newborn (ICD 770). The ICD codes for the full population data are: pulmonary congestion and accumulation of fluid (ICD 514); extrinsic allergic alveolitis (e.g., "farmer's lung", ICD 495); and other diseases of the lung (ICD 518, excluding 518.5, surgery following trauma). The Pearson correlation between the newborn data and glyphosate applications is R=0.949 and for all ages (except newborn) R= 0.971.

Liver disease

An increasing number of mammals and birds have been observed with liver tumors, enlarged liver or liver involution. Figure 24 shows several examples of liver disease in wildlife, including tumor-like growths in a wolf (*Canus lupus*), a domestic goat, a fledgling Rock

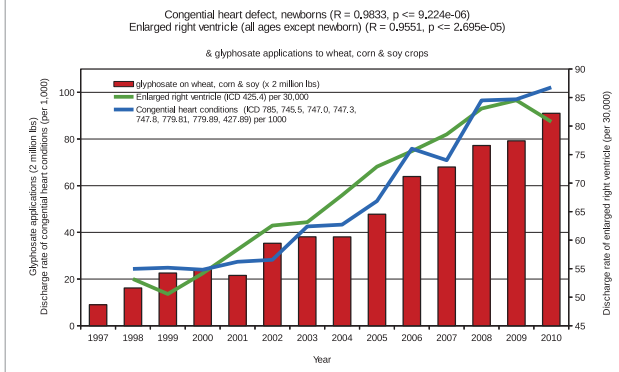

Figure 22: Hospital discharge rates for congenital heart conditions; enlarged right ventricle (ERV) for all ages (except newborn); superimposed with glyphosate applications to wheat, corn and soy crops. The congential heart conditions include: heart murmur (ICD 785.2); ostiumsecundum type atrial septal defect (ICD 745.5); patent ductusarteriosus (ICD 747.0); pulmonary artery anomalies (ICD 747.3); other congenital anomalies of circulatory system (ICD 747.8); other heart/circulatory conditions originating in the perinatal period (ICD 779.89); and bradycardia (ICD 779.81,427.89). The Pearson correlation coefficient between congenital heart defects and glyphosate applications is R=0.9833. The Pearson correlation coefficient between the ERV for all ages and glyphosate applications is R=0.9551.

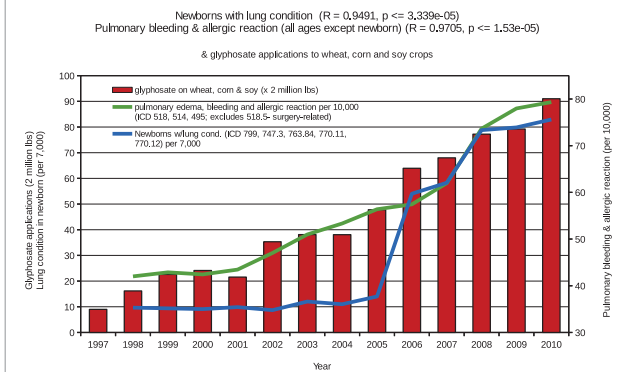

Figure 23: Hospital discharge rates for newborn lung conditions; pulmonary bleeding and edema for all ages (except newborn); superimposed with glyphosate applications to wheat, corn and soy crops. The Pearson correlation coefficient between the pulmonary disorders and glyphosate is R=0.9705. The newborn lung conditions include: asphyxia and hypoxemia (ICD 799); pulmonary artery anomalies ICD 747.3); other respiratory conditions of fetus and newborn (ICD 770); meconium passage during delivery (ICD 763.84); meconium aspiration with and without respiratory symptoms (770.11 and 12). The Pearson correlation coefficient between the newborn lung conditions and glyphosate applications is R=0.9491.

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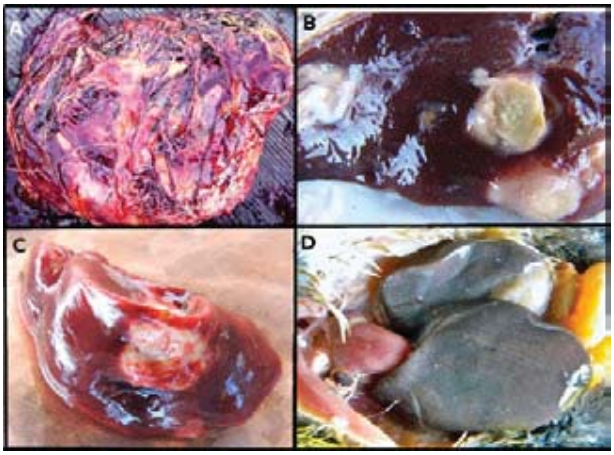

Figure 24: Liver conditions in wildlife. A. Large tumor verified as cancer, 18 cm. (7 in.) in diameter, removed from the outside of the liver on a female grey wolf. B. Tumor-like growths in the liver of an adult female domestic goat. C. Tumor-like growths in the liver of a fledgling Rock Pigeon. D. A Black-billed Magpie fledgling's enlarged, discolored liver.

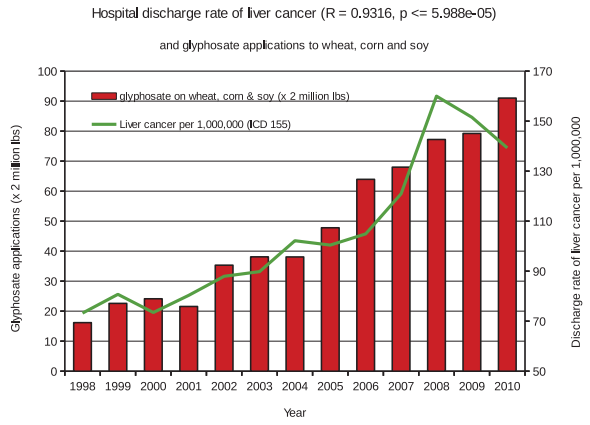

Figure 25: Hospital discharge rates of liver cancer for all ages (except newborn) along with glyphosate applications to wheat, corn and soy crops. The Pearson correlation coefficient between the prevalence of liver cancer and glyphosate applications is R=0.9316.

Pigeon (*Columba livia*), and the enlarged, discolored liver of a Black-billed Magpie fledgling.

Liver cancer in humans has also been increasing in frequency in the United States over the past two decades, with a shift towards relatively younger ages [14]. Similar trends are seen in China [15]. Figure 25 shows the hospital discharge rates of liver cancer in all ages (except newborn), alongside glyphosate usage on core crops. The Pearson correlation coefficient is R=0.932.

Congenital urogenital malformations

Birth defects of the male reproductive organs (Figures 26 and 27) have become common on mammals in Montana and appear to be occurring in some wildlife populations over much of the US [16,17]. The decrease in penis sheath length, scrotum size and the change in testes position in Montana are depicted in Figures 28 and 29. Several of the reproductive malformations have not been well studied, especially misplacement forward of the inguinal lymph node and the left spermatic cord, resulting in misalignment of the testes and corresponding hemiscrota during fetal formation of the scrotal sac (Figure 26C, 26E and 26F). This easily observed reproductive malformation was first reported in a 2002 study of white-tailed deer [10]. It has become very high in prevalence in white-tailed deer (Figure 30), and appears to also be high in several Western Montana rodent species, especially the introduced eastern fox squirrel (Figure 27). In

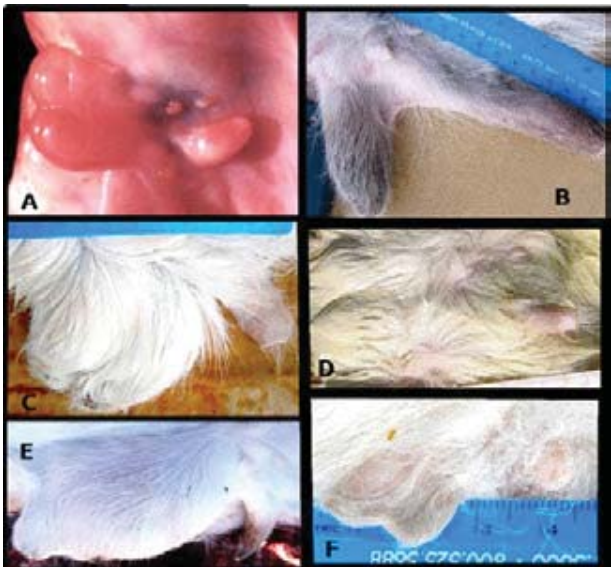

Figure 26: Normal and abnormal white-tailed deer male genitalia. A. White-tailed deer fetus, normal genitalia. B. One-year-old white-tailed deer, normal genitalia. C. One and 1⁄2 year-old white-tailed deer with misaligned hemiscrota and short penis sheath. D. One and 1⁄2 year old white-tailed deer, no scrotum formed on external skin, testes ectopic under the skin (see bumps), short penis sheath. E. Two-year-old white-tailed deer, horizontal misaligned hemiscrota, penis sheath normal. F. Newborn white-tailed deer with misaligned hemiscrota and short penis sheath.

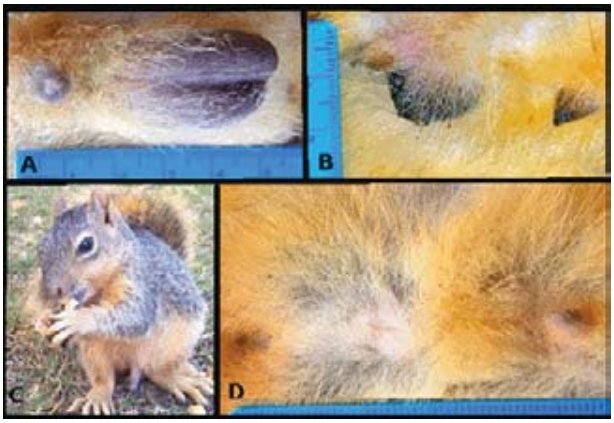

Figure 27: Normal and abnormal eastern fox squirrel male genitalia. A. Normal scrotum, very short penis sheath. B. Scrotum is misaligned with short empty skin flaps, penis sheath very short. C. White spot where scrotum should be formed, penis sheath very short. D. Live juvenile male with normal penis sheath for comparison.

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27 specimens of male eastern fox squirrel examined by Hoy from 2010 through 2014, 78% (21) had no hemiscrota formed and 7% (2) had one hemiscrota formed, all with ectopic testes, leaving only 15% (4) with a normal scrotum containing both testes. On 89%, (24) the penis sheath was less than half normal length.

Figures 28 and 29 show our data collected from WTD from 1995 to 2010 on penis sheath length (Figure 28) and testes position and scrotum length (Figure 29). In almost all years, fewer than half of the animals examined had a normal configuration. Notably, in 2006, 100% of the animals examined had ectopic testes, and more than 90% had a misaligned scrotum.

Figure 31 shows newborn genitourinary disorders compared to glyphosate applications to wheat, corn and soy crops. The human disorders include: hydrocele (watery fluid around the testicles) (ICD 778.6); hypospadias (ICD 752.6); hydronephrosis – obstruction of urine flow (ICD 591); and other disorders of the kidney and ureter (ICD 593). The Pearson correlation coefficient between genitourinary disorders and glyphosate applications is R=0.959.

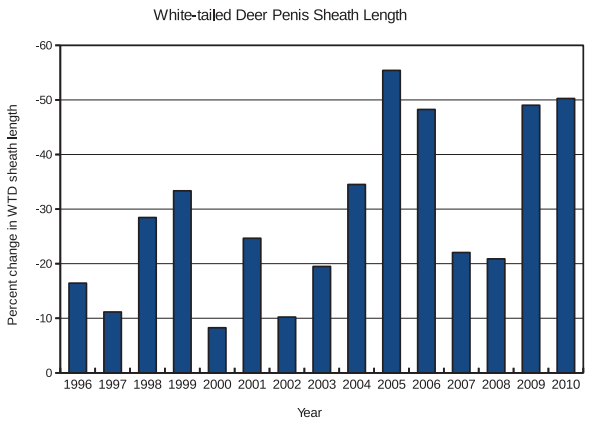

Figure 28: Percent change in white-tailed deer penis sheath length, 1996-2010.

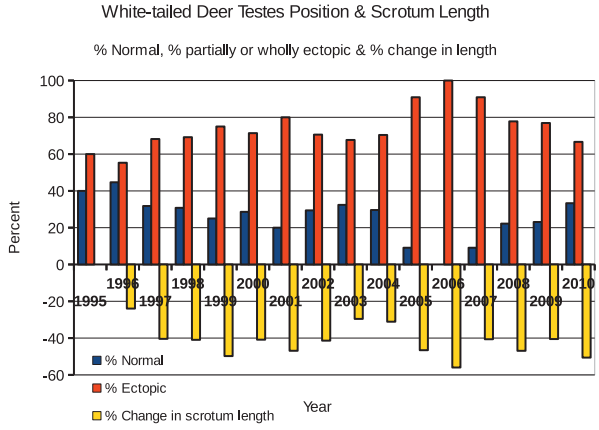

Figure 29: White-tailed deer testes position and scrotum length, 1995-2010.

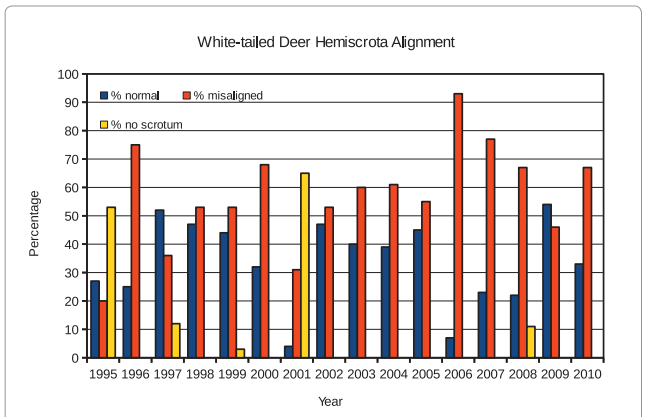

Figure 30: White-tailed deer hemiscrota alignment,1995-2010.

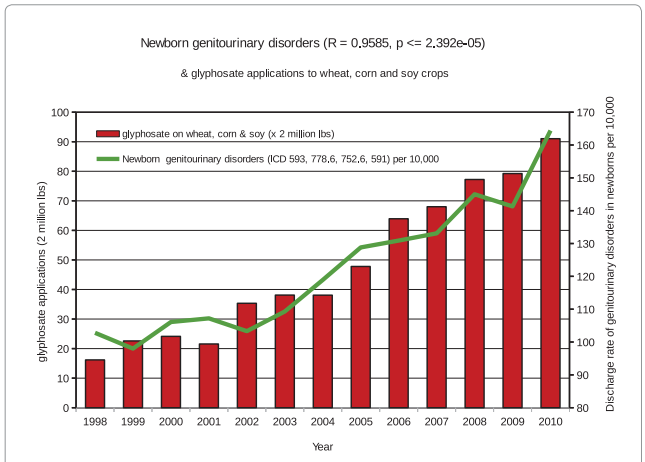

Figure 31: Hospital discharge rates for newborn genitourinary disorders compared to glyphosate applications to wheat, corn and soy crops. The genitourinary disorders include: Other disorders of the kidney and ureter (ICD 593); hydrocele (watery fluid around one or both testicles (ICD 778.6); hypospadias (ICD 752.6); and hydronephrosis- obstruction of urine flow (ICD 591). The Pearson correlation coefficient between the genitourinary disorders and glyphosate use is R=0.9585.

Failure to thrive

Failure to thrive, observed on multiple species of wild newborns, is a recognized problem in livestock, and may well be related to human failure to thrive. For example, porcine periweaning failure-to-thrive syndrome (PFTS) is an increasingly recognized syndrome in the swine industry in North America [17]. It is characterized by anorexia developing within one week of weaning followed by lethargy and, in some cases, death.

We examined the data in human newborns for comparison and found that a number of metabolic disorders have been increasing in frequency in human newborns, as illustrated in Figure 32, in step with glyphosate applications to wheat, corn and soy crops. Included are: disorders of fluid electrolyte and acid/base balance (ICD 276); underweight, feeding problems and fetal malnutrition (ICD 783); disorders of mineral metabolism (ICD 275); slow fetal growth and fetal malnutrition (ICD 764); and other congenital anomalies of the

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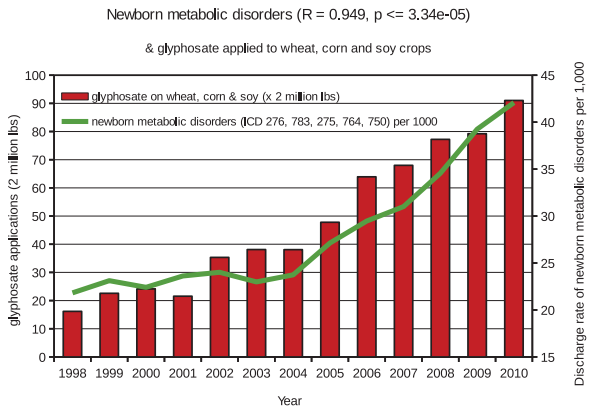

Figure 32: Hospital discharge rates for newborn metabolic disorders compared to glyphosate applications to wheat, corn and soy crops. The metabolic disorders include: disorders of fluid electrolyte and acid-base balance (ICD 276); underweight, feeding problem & fetal malnutrition (ICD 783); disorders of mineral metabolism (ICD 275); slow fetal growth and fetal malnutrition (ICD 764); other congenital anomalies of upper alimentary tract (ICD 750). The Pearson correlation coefficient is R=0.949.

upper alimentary tract (ICD 750). The Pearson correlation coefficient between these two plots is R=0.949.

Discussion

One of us (Hoy) has been documenting health status of wild animals in the mountains of Western Montana for over forty years. She has noticed a significant degradation in health over the past two decades, mainly consistent with mineral deficiencies and thyroid hormone disruption, and she surmises that the health issues are related to exposure to various pesticides being applied to crops in close proximity to the animals' habitat. Besides exposure from nearby applications, many pesticides have been shown to travel on fast-moving weather fronts to come down in rain or snow many hundreds of miles from the application site [18,19]. Low level exposure to 60% of all herbicides applied in the US are known to interfere with thyroid function, in particular 2,4-dichlorophenoxacetic acid (2.4-D) [20]. Glyphosate, another thyroid hormone disrupting herbicide [21], has also been shown to chelate multiple minerals essential to normal fetal development and health of adult animals, and to disrupt retinoic acid [22,23]. A large number of field studies have "found an association between exposure to environmental contaminants and alterations in thyroid gland structure, circulating thyroid hormones and vitamin A (retinoid) status" in multiple populations of wild vertebrates [23]. The proper quantity of minerals, retinoic acid and thyroid hormones are essential to normal development and growth as well as sustaining health during the life of the animal. Thus, exposure to environmental contaminants often results in "reproductive and developmental dysfunction" in all vertebrate classes [24].

In this paper, we present some of the evidence Hoy has gathered, and we use it to inspire investigations on human health status in the general US population. While the animals' exposure is likely mostly through water and air, we believe that human exposure is predominantly through food, as the majority of the population does not reside near agricultural fields. We have obtained government data on pesticide usage from the USDA and on human disease patterns over time from the CDC's hospital discharge data, available from 1998 to 2010. Since glyphosate is by far the most widely used herbicide, we believe it to be a major source of contamination for the humans, and any correlations between glyphosate usage over time and specific health issues is likely to reflect a causal relationship. The research literature can help to clarify whether conditions whose incidence is rising in step with rising glyphosate usage could plausibly be caused by glyphosate, given its known toxicology profile.

Most of our graphs illustrating human disease patterns involve infants, but we also present evidence from children 0-15 and from the full population excepting newborns. We found many diseases and conditions whose hospital discharge rate over the twelve-year period match remarkably well with the rate of glyphosate usage on corn, soy, and wheat crops. These include head and face anomalies (R=0.95) (Figure 10), newborn eye disorders (Figure 13), newborn blood disorders (Figure 15) (R=0.92), newborn skin disorders (R=0.96) and skin disorders in the general population (R=0.90). (Figure 17), lymph disorders in children 0-15 (R=0.86) and in the general population (R=0.89) (Figure 19), congenital heart conditions in newborns (R= 0.98) and enlarged right ventricle in all age groups except newborn (R=0.96) (Figure 22), newborn lung problems (R=0.95) and pulmonary bleeding and edema for all age groups except newborn (R=0.97) (Figure 23), liver cancer (R=0.93) (Figure 25), newborn genitourinary disorders (R=0.96) (Figure 31) and newborn metabolic disorders (R=0.949) (Figure 32).

Glyphosate's established mode of action in killing weeds is through disruption of the shikimate pathway [22,25] whose products, the essential aromatic amino acids, are important precursors to multiple biologically important molecules, including the neurotransmitters dopamine, serotonin, melatonin, and epinephrine, the B vitamin, folate, the molecule nicotoinamide dinucleotide (NAD) involved in many redox reactions, and the tanning pigment, melanin [24,26]. Gut microbes produce the aromatic amino acids using the shikimate pathway, so this ability is impaired in the presence of glyphosate. A general mode of action of glyphosate is that it chelates the soluble ions of many mineral nutrients including calcium, copper, iron, magnesium, nickel and zinc, which are essential cofactors in many specific biochemical reactions [25,27]. Glyphosate has been shown to disrupt the gut microbiome in animals, probably in part through disrupting mineral bioavailability, including manganese, iron, zinc, and cobalt [22,24]. Impaired manganese homeostasis can explain many features of disorders whose incidence is rising in the human population, including autism, Alzheimer's disease, Parkinson's disease, osteoporosis, and rheumatoid arthritis [28]. Multiple pathogenic infections due to gut dysbiosis are a major factor in the decline in orcas (*Orcinus orca*) along the north Pacific coast of the US [29], and glyphosate exposure is a likely contributor.

The newborn is highly susceptible to oxidative stress produced by free radicals [30-32]. An excess of free radicals is implicated in neonatal chronic lung disease [33], which rose sharply in the newborn population in 2006 and was highly correlated with glyphosate usage (Figure 23). Inflammation, hypoxia, ischemia, glutamate, and free iron magnify the effect of free radicals [30]. Glyphosate suppresses the first step in the synthesis of the pyrrole ring, a core structural component of heme [34-36], leading to excess bioavailability of free iron. Glyphosate also, through its chelation of manganese, disrupts the synthesis of glutamine from glutamate, because the enzyme glutamine synthase depends on manganese as a catalyst [28]. Glyphosate can be expected to induce hypoxia by interfering with hemoglobin synthesis. Furthermore, melatonin is a highly effective antioxidant [32], but its

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synthesis depends on the shikimate pathway. Melatonin appears to be both safe and effective as a supplement to treat oxidative stress in newborns [32], and it is possible that melatonin deficiency due to poor bioavailability of its precursor molecule, the shikimate pathway product tryptophan, is contributing to increased oxidative stress in newborns.

Many pesticides, including chlorothalonil and glyphosate, have been shown to work synergistically to more quickly damage vital biological processes in the cells of plants and animals [37,38]. Combinations of pesticides that chelate minerals and disrupt endocrine functions can easily have synergistic effects at extremely low doses that are not predicted by the effects found at higher doses in common toxicity studies. The National Toxicology Program defines the low-dose effects of pesticides we have commonly observed on wildlife as those effects that occur in the range of human exposures or effects observed at doses below those used for traditional toxicological studies [39]. Epidemiological studies present strong evidence that exposures to far lower levels than the concentrations of environmental toxins now found in most air and water samples are associated with diseases and birth defects in all vertebrate classes [15,40]. Glyphosate has been shown to be an endocrine disrupting hormone, able to induce growth of breast cancer tumor cells in concentrations of parts per trillion. This is well below the level usually studied in toxicology investigations [39,41]. Estrogenic compounds like glyphosate can cause sexual reversal during development in alligators, as demonstrated in studies in Florida, particularly if exposure occurs during a critical period of gestation [42].

The patterns over time for the wild animals and the humans are distinctly different, and we believe that the explanation for the high levels of defects in the early years in the wild animals, as contrasted with the humans, are due to exposure to other pesticides besides glyphosate. Between 1997 and 2006 the use of chlorothalonil and other fungicides on potato crops for blight steadily decreased in states directly upwind of our wildlife study area. There was a corresponding observable decrease in the birth defects in mammals and birds in Western Montana. When the more severe birth defects that cause mortality went down, more wild young began to survive, especially those of wild ruminant species in serious decline. By spring of 2006, the facial malformations on grazing animals had decreased to approximately half the 2001 prevalence, and the populations of white-tailed deer and other wild ungulates were steadily going up from 2002 through 2006. However, the wild ungulate populations declined sharply in subsequent years, closely corresponding with the increase in use of glyphosate after 2006 (Figures 2-8).

In addition to the well-documented effect of disrupting normal hormone functions [39], many toxic chemicals, including commonly used herbicides such as 2,4-D, picloram, and glyphosate as well as some fungicides, including chlorothalonil, adversely affect the mitochondria of the cells and disrupt energy metabolism [41,43]. Manganese is a cofactor in the important antioxidant enzyme in mitochondria, manganese superoxide dismutase (Mn-SOD). Mn-SOD plays an important role in defense against inflammation [44], known to be a major factor in cancer. Undoubtedly, such deficits in metabolism would seriously affect the ability of a pregnant female to maintain normal weight and health and would inhibit normal fetal growth, as well as a newborn's ability to maintain heat, energy and normal growth.

Evidence of increased toxicity of glyphosate formulations

The toxicology experiments used by regulatory agents to decide whether to approve a new chemical explicitly require that the active ingredient be evaluated only in isolation [45]. Glyphosate formulations are trade secrets, but they often contain other ingredients that either make glyphosate itself more toxic to cells or are themselves innately toxic [46,47]. Polyethyoxylated tallowamine (POEA) is used in many formulations as a common surfactant to improve glyphosate's effectiveness. By 2006, nearly all of the glyphosate usage was in the form of the salt formulations. Other herbicides were also converted to salt formulations, including 2,4-D and Dicamba. With continuously increasing use of the herbicide salt formulations, the symptoms of fetal hypothyroidism and multiple mineral deficiencies have increased alarmingly in wildlife.

Studies on rat liver mitochondria revealed that Roundup at 15 millimolar concentration collapsed the transmembrane potential, caused mitochondrial swelling and depressed respiration by 40% [48]. Glyphosate alone did not exhibit this effect. In vitro studies showed that only 1 to 3 ppm of POEA is enough to produce toxic effects on cellular respiration and membrane integrity [49]. The lipophilic character of POEA gives it the ability to penetrate cell membranes, and probably also enables glyphosate to gain access to cells. In addition, the salt-based formulations are suspected to be much more deadly to humans who attempt suicide through glyphosate ingestion [49].

Both glyphosate and chlorothalonil suppress cytochrome p450 (CYP) enzyme activity, resulting in a gradual depletion of the vital functions in the liver performed by the CYP enzymes [26,50]. CYP enzymes are responsible for the activation of Vitamin D, and they play a role in the production of bile acids and the synthesis and/or metabolism of cholesterol, testosterone, estrogen, progesterone and other corticosteroids. The suppression of CYP enzymes in the liver can be expected to greatly increase the toxicity of all xenobiotics to the liver, but it also has serious adverse effects on the immune system and other organ functions, including the reproductive organs [28]. While the fatality rate for glyphosate attempted suicide or accidental exposure had been relatively low in earlier reports, a paper published in 2008 claimed a fatality rate of nearly 30% [51]. Symptoms associated with human acute poisoning with glyphosate included respiratory distress, altered consciousness, pulmonary edema, shock, dysrrhythmia, and renal dysfunction. Pulmonary and renal toxicity lead to mortality in humans, following metabolic acidosis and tachycardia [49]. Exposure of glyphosate to piglets in controlled experiments showed that the POEA-based formulation was much more toxic to the piglets [52]. Multiple adverse cardiovascular effects were observed, including pulmonary hypertension, circulatory collapse, and acute metabolic acidosis.

Additionally, in spring of 2006, a relatively new class of neonicotinoid insecticides, which bear a chemical resemblance to nicotine, began being used throughout the US and in other countries. These may well have synergistic effects with glyphosate, due to glyphosate's suppression of CYP enzymes, which are needed for detoxification of neonicotinoids [53]. Our own observations on multiple disease trends in the US population reveal a sharp increase in hospital discharge rates for the health problems addressed herein around the 2006 time frame, which we hypothesize may be connected to the widespread switch to glyphosate salt-based formulations, as well as the introduction of neonicotinoids.

There was a corresponding increase after 2005 of birth defects and serious health problems on white-tailed deer fawns and other animals. This included a significant increase in enlarged right heart ventricle, lung damage, dilated lymphatic vessels on the heart surface and underdeveloped or damaged thymus on newborn white-tailed deer

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necropsied by Hoy. The original formulation of glyphosate had been shown to cause dilated heart on rabbit fetuses, and the percentage of rabbit fetuses with dilated heart was significantly elevated at all dose levels along with skeletal variations, anomalies and malformations [54]. We also observed congenital heart conditions in newborns as well as impaired lung function and enlarged right ventricle in human data (Figures 22 and 23), trending upward in step with glyphosate usage.

An extremely serious health issue with the hooves of wild ruminants began around 2007 in many areas of the United States and Canada. Moose, elk, deer, bighorn sheep and possibly other wild ungulates were observed to have disrupted growth of the keratin of the hooves, causing malformed hooves, severe lameness and resultant mortality. Laminitis has been increasing in horses throughout the United States. The keratin of the hooves of ungulates has a significant amount cholesterol sulfate in its composition, as shown in tests of horse hooves [55]. Impaired cholesterol sulfate synthesis appears to be a primary toxicity path of glyphosate [26].

Below, we will discuss some of our specific findings in more detail and link them to the research literature on animal exposures and on the effects of glyphosate and other pesticides on biological systems.

Congenital head and facial malformations

Glyphosate's mineral chelating effects result in vital minerals being unavailable to the developing cells of vertebrate young. A primary mode of glyphosate action is chelating manganese. The most common birth defect on the white-tailed deer fawns is brachygnathia superior [10], shown to be caused by fetal mineral deficiencies, particularly manganese deficiency [56-58]. This is likely connected to the important role that manganese plays as a catalyst in the production of chondroitin sulfate, which is crucial for bone development [28,59].

Given the documented increase in incidence of underdeveloped facial bones, it appears that young of both bird and mammalian species are being affected by an agent, or more likely a combination of agents, that interfere with bone growth. Our studies on the CDC hospital discharge data revealed that human infants show a rise in disorders of mineral metabolism, specifically for the three minerals, calcium, magnesium, and phosphorus (Figure 32). Human infants are also experiencing an increase in anomalies of the head and face that matches well with glyphosate usage (Figure 10). Many environmental toxins have been shown to interfere with intracellular calcium levels and bone growth in developing animals [60]. Exposure of a mammalian fetus to pesticides more than doubles the risk of mortality due to developmental malformations [61]. Exposure of bird embryos to dioxin resulted in malformed skulls and brains [62]. It is likely that disruption of both calcium and energy metabolism would have an adverse influence on normal ossification, resulting in the underdevelopment of the skull, maxilla, leg bones and more rarely other skeletal bones, as has been observed on wildlife.

Congenital thymus malformations, lymph system and thyroid

The thymus of animals exposed to toxic pesticides is often very obviously damaged upon postmortem examination, as illustrated in Figure 14. Thymus and spleen development take place mainly in the postnatal period, and zinc deprivation during this critical time in mice can result in a markedly reduced size of the thymus [63,64]. Thymus involution due to apoptosis has also been implicated in association with magnesium deficiency [65,66].

Glyphosate's chelating effects on +2 cations could lead to zinc and magnesium deficiency in exposed individuals. Glyphosate has been shown to deplete zinc as well as manganese in glyphosate-resistant soy crops [67]. Studies on rats have shown that melatonin, a product of the shikimate pathway, protects the thymus from oxidative damage [68].

Monsanto's own studies showed that exposure of albino rats to a dust aerosol containing pure glyphosate for four hours led to lesion development on the lungs and thymus in the form of red foci [69]. These align well with the red spots that were observed on thymuses from newborn white-tailed deer in our Figure 14C, 14D and 14E.

Impairment in the thymus logically leads to disorders of the lymph system, which have increased dramatically, especially since 2006, in both children and the general population (except newborn) (Figure 19). Magnesium deficiency is linked to impaired immune function [70].

The thyroid modulates endocrine activity of the thymus, and thymulin levels are correlated with thyroxin 3 (T3) and T4 levels [71]. Human hypothyroidism may therefore be related to the observed defects in thymuses of animals exposed to toxic chemicals. The trend over time of hypothyroidism among children aged 0-15 aligns remarkably well with brachygnathia in deer fawns (Figure 11). Low magnesium was shown to decrease production of the most important form of Vitamin D, essential in bone development [72]. We hypothesize that these two patterns may be linked through manganese dysbiosis. In [28], it was proposed that glyphosate leads to an excess of manganese in the brain stem and a deficiency in the vasculature, due to impaired bile flow in the liver. Excess manganese in the brain stem has been hypothesized to damage thyroid function both through direct damage to the thyroid and through dysregulation of dopaminergic modulation of thyroid hormone synthesis [73].

Newborn rats in a multi-dose study showed developmental effects and delayed sexual maturation at all doses of Chlorothalonil [74]. Chlorothalonil is a nitrile as are its metabolites. It consists of two cyanide molecules attached to a hexachlorobenzene ring. Cyanide has been shown to disrupt thyroid hormone functions, especially during fetal development [75]. Additionally, many herbicides, particularly 2,4-D and Dicamba, disrupt normal thyroid hormone function [20], thus a cumulative or synergistic effect between the organochlorine pesticides and glyphosate should be considered.

Reproductive system

Endocrine disruption is trans-generational because a mother can accumulate toxic chemicals in fat tissues over many years, which are mobilized during pregnancy and lactation, to cause harm to the fetus or infant [76]. Each stage in the development of fetal reproductive organs requires precise amounts of hormones and enzymes, in addition to other factors, such as temperature, in some species of vertebrate. An alarming study of deep-water fish in the Bay of Biscay (northeast Atlantic Ocean) published in March 2015, found a wide variety of inflammatory and degenerative lesions in all species examined, in addition to diseases of the liver, and the first case of an intersex deep-water fish [76]. In a study of pollutants in National Parks, male fish were found to have female sex organs caused by pesticides in high mountain lakes in Glacier National Park, considered to be a pristine area, only150 miles north of our wildlife study area [77].

Conversion of testosterone to estrogen by aromatase depends on CYP enzymes. Aromatase activity is decreased by glyphosate [78]. Glyphosate also decreases serum testosterone concentrations.

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Exposure to the commercial formulation of the herbicide glyphosate alters testosterone levels and testicular morphology in prepubertal males [79]. Glyphosate also inhibits steroidogenesis and other normal functions of adult male reproductive organs, including the testicular cells [80,81].

Glyphosate caused cytotoxicity to progesterone-producing cells in vitro at levels that were comparable to the allowable levels in drinking water, leading to a decrease in progesterone production, and Roundup was more toxic than glyphosate [82]. Endocrine disrupting effects of Roundup on human female cells, and the activity of the pituitary-derived regulatory gonadotrophin, luteinising hormone (LH), and embryo-derived chorionic gonadotrophin (CG) activity, have not been sufficiently examined and may be contributing to the low reproductive rates in many wildlife species.

Glyphosate working synergistically with other pesticide exposures, disrupting normal hormone and enzyme levels and/or functions at key periods during fetal development, are the most likely cause of the variety of birth defects found in white-tailed deer and other wild ruminant populations since spring 1995 [10,11].

The decreased aromatase activity caused by glyphosate and possibly other pesticides may be responsible for the highly skewed sex ratio in favor of males found in Western Montana white-tailed deer fawns [10]. Studies considering the maternal condition prior to conception provide strong evidence for a relationship between maternal condition and the sex ratio in mammals [83], particularly in wild ungulates such as white-tailed deer [84]. Mineral deficiencies, damaged mitochondria and hormone disruption would certainly have an adverse effect on the condition of a pregnant female, especially in the wild. The sex ratio significantly skewed in favor of males began occurring in the Western Montana white-tailed deer fawns the same spring as the birth defects [85]. Most importantly, in 1995, marine mammals and vertebrates in other areas began being documented with unusual health problems and high rates of mortality in breeding age females and newborns [86,87].

Congenital urogenital malformations

Since 1995, an increasing prevalence of male reproductive malformations [16,24] has been observed on multiple vertebrate species. Analogous birth defects on vertebrates have more recently been shown to be the result of glyphosate exposure [88] as well as other pesticides [42]. Birth defects have been observed on multiple mammalian species [89], including human newborns [90], many individuals of multiple bird species [91,92], on reptiles, particularly alligators [93-95], and on multiple species of amphibian [96-98].

Disrupted development of the male genitalia, resulting in shortening of the penis sheath and/or the scrotum on the external skin, has been shown to be caused by a combination of zinc deficiency, disruption of retinoic acid (Vitamin A), Congenital Fetal Hypothyroidism (CFH) and dihydrotesterone (DHT) disruption, all factors symptomatic of exposure to glyphosate [26,88].

Zinc deficiency in both a pregnant female and her male fetus or fetuses is likely a contributing cause of the shortening of the penis sheath, the underdevelopment of one or both hemiscrota, and possibly of the misalignment of the hemiscrota [99,100]. Cellular zinc levels have a strong influence on the 5-alpha reductase inhibitor, which converts testosterone into DHT. DHT is instrumental in the normal growth and development of external male reproductive organs because DHT bonds to androgen receptors more effectively than other natural androgens [101]. In addition, low levels of retinoic acid (vitamin A) have been connected to zinc deficiency in developing fetuses [102,103]. Also, retinoic acid receptor alpha, a receptor for retinoic acid, has profound effects on vertebrate development by directly regulating gene expression [104].

The disruption of vitamin A caused by ingesting glyphosate [88] would likely have serious effects in the digestive system of ruminants, which may be why they appear to be highly affected by health problems and birth defects. In ruminants, significant amounts of vitamin A are degraded in the rumen, while digestibility of carotene varies in different species [105]. There are also several variables that influence carotene digestibility and vitamin A content in forage including the type of forage, the plant species ingested and the month forage is eaten, being above average during warmer months and below average during the winter. Vitamin A levels depend on adequacy of dietary fat, protein, zinc, phosphorus and antioxidants, which can be seriously lacking in the diets of wild ruminants in winter when the females are carrying developing fetuses. Vitamin A deficiency has been shown to cause lung and liver damage in rats [106].

With increasing use of glyphosate, the amount of glyphosate and other toxins in or on the ingested foliage is likely a primary factor affecting zinc and retinoic acid levels. Depending upon their size, ruminants ingest a large amount of foliage each day, resulting in consumption of biologically significant levels of glyphosate. Cellular zinc levels have a strong influence on the 5-alpha reductase inhibitor, which converts testosterone into DHT. DHT is instrumental in the normal growth and development of external male reproductive organs because DHT bonds to androgen receptors more effectively than other natural androgens [107].

Glyphosate and its synergistic effects with other pesticides, such as Chlorothalonil, are likely closely connected to the increasing prevalence of birth defects and health problems affecting the male reproductive organs since 1995 [10,11,85]. For example, genital hypoplasia, now very common, was almost unknown on white-tailed deer in years prior to 1995 [108] (Figures 28-30). A Danish study showed a steady increase in the incidence of hypospadias in boys from 1977 to 2005 [109]. Glyphosate became available on the market in 1975. Our own data show remarkable correspondence between newborn genitourinary disorders, including hypospadias, and glyphosate usage on crops (Figure 31) (R=0.96).

Thyroid hormone disrupting chemicals act synergistically such that the combined effects are greater than linear. It can be expected that simultaneous fetal exposure to glyphosate and chlorothalonil would synergistically suppress CYP enzymes, as well as thyroid hormone functions, likely resulting in even more severe teratogenic effects than that caused by exposure to either alone. Added to the depletion of cellular zinc and the disruption of gonadotropin expression caused by glyphosate [78,110] the result is a significant assault on the growth and development of the male genitalia.

Conclusion

Something is causing alarming increases in diseases and birth defects in wildlife. Something is causing alarming increases in diseases and birth defects in humans. Our graphs illustrating human disease patterns over the twelve-year period correlate remarkably well with the rate of glyphosate usage on corn, soy, and wheat crops.

Glyphosate is known to chelate vital minerals [US Patent #3160632 A]. Glyphosate is an anti- microbial and biocide [US Patent #20040077608 A1]. Glyphosate has been classified as an endocrine

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disruptor by the Endocrine Society. Glyphosate has been classified as "probably carcinogenic" by the World Health Organization and by the American Cancer Society. Glyphosate interferes with the shikimate pathway, essential to healthy gut microbes. Glyphosate inhibits the CYP enzyme activity, which is vital to a healthy functioning liver.

The strong correlations between glyphosate usage and disease patterns, the highly significant p-values and the known toxicological profile of glyphosate indicate that glyphosate is likely a major factor in the increases in the serious issues with human health documented here.

Our over-reliance on chemicals in agriculture is causing irreparable harm to all beings on this planet, including the planet herself. Most of these chemicals are known to cause illness, and they have likely been causing illnesses for many years. But until recently, the herbicides have never been sprayed directly on food crops, and never in this massive quantity. We must find another way.

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Glyphosate, Roundup, Glyphosate-Tolerance GM Soybeans, Chemical Extracted Soybean Food Oil/Soybean Powder Cause Serious Harm to Health of American/Chinese People

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June 18, 2014

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4. Twenty-four international and Chinese and scientific studies and epidemiology studies prove that hexane residuals and benzene residuals cause reproduction toxicity to both female and males

Twelve Health Deteriorate Trends in Both USA and China

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5）USA and China's Patients Reason Unclear Increase During Past Ten Years: 44% of Americans in 2005 had at least one chronic medical condition; Chinese residents with chronic disease is already 20%, the total number of determined diagnosed chronic patients reach 260 million. During past ten years, there are 10 million chronic disease patents newly diagnosed each year.

6) 8.3% Americans Have Diabetes, 9.7% Chinese Have Diabetes Exceeding USA, the Risk is Very High for the "East Asian Weakling" Nightmare to Arrive Again for China!

7）About one in every 33 babies (about 3%) is born with a birth defect, including approx 1% diagnosed with congenital heart defects in USA; the incidence of newborns with defects in China at present is about 5.6%, the incidence of newborns with defects shows a trend of increase, increased from 877,000 in 1996 to 1.499 million in 2010, increase rate 70.9%, with congenital heart disease becomes the number one defect!

8) In USA, 78% increase of autism during 2007 - 2010, In China, autism rate in various areas has reached 1.5%, increased 10 times over 20 years, environmental, chemical, biological factors pointed as the culprit!

9) Studies indicate possible links between Alzheimer's disease and Parkinson's disease, indicate 10% increase of annual incidence of Alzheimer's disease from 2000 to 2010 in USA; During the past 20 years (1998 - 2008), the average ages of Alzheimer's disease patients has advanced from 65 years to 55 years; In the USA, 50,000-60,000 new cases of Parkinson disease are diagnosed each year; Based on most conservative estimations, the incidence of Parkinson disease during recent 20 years in China has at least increased over 20 times!

10) 1988-2004 USA incidence of primary liver cancer rapidly rose 90%, China's liver cancer patients accounts for 54.26% of World's total

11) Children cancer increasing, especially leukemias, dramatically increased in USA and China.

12) Inflammatory Bowel Diseases rapidly increased 65 percent increase from 2000 to 2009, and increased 12 times in Shanghai from 2003 to 2013!

1）USA Infertility Reaching 15%, China Closely Following Infertility Patients Already Exceeding 50 Million

USA infertility continue increases: 1995 10%; 2002 12%; 2009 15%

- **1995:** According to National Survey of Family Growth, CDC 1995, **approximately 6.1 million women and their partners in the U.S. are affected by infertility, i.e., 10% of the total reproductive-age population**. [2]
- **2002: Infertility affects about 7.3 million women and their partners in the U.S. -- about 12% of the reproductive-age population** (Source: *National Survey of Family Growth, CDC 2002*). [3]
- **2009**: **Based on reported cases alone, almost 15 percent of adult Americans experience infertility.**Despite medical advances in the treatment of infertility over the last two decades, that rate has not declined. In fact, most experts believe it has risen. Meanwhile, as the population of the United States has grown since 1970, the number of infertile couples has more than doubled. **At present, an estimated 9 million individuals are affected by infertility.** [4]

China：In China, the rate of infertile couples has reached 1/8, the number of infertile patients has exceeded 50 million!

- Wu Jing-chun, Executive Committee Member of China Women Federation, former Deputy Director of China Birth Planning Commission, on the "Sino-U.S. Infertile Academic Forum" held in Dec., 2011 stated, due to various factors and work pressure, the ratio of infertile couples have reached 1/8, infertile patients have exceeded 50 million in China, and are gradually increasing. She said, a birth crises is approaching. [5]
- Prof. Chen Qiu-bo, honorary director, Hangzhou Guangren Infertility Research Institute, in March 2012 pointed out: Statistics show, the infertility incidence among appropriate age couples is sharply increasing, the average incidence in the country is 12.5%-15%, meaning, one infertility among each 8 couples. [6]

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2）Precocious puberty Rapidly Increase in both USA and China

USA:

About 15 percent of American girls now begin puberty by age 7, according to a study of 1,239 girls published last year in the journal Pediatrics. One in 10 white girls begin developing breasts by that age - twice the rate seen in a 1997 study. Among black girls, 23 percent hit puberty by age 7. [1]

China:

- The age of children in Guangzhou entering puberty has from average 13 years old advanced to 11 years; Based on study of a few thousand children in Guangdong province, the rate of "early puberty" has increased from 0.5% in 1994 increased to 1.3% in 2004, the average rate of "early puberty" in China is 1%. [2]
- Early puberty rate survey of 23 thousand children in Zhejiang coast area reveals: 84 children were identified early puberty, 9 boys and 75 girls, indicating rate of early puberty 0.38%, and girls with early puberty is 7.3 times of boys.
- The survey also revealed that the rate of early puberty is 0.45% in cities and towns, higher than 0.32% in rural areas; 0.50% in economic developed areas, and 0.32% in undeveloped areas; 0.52% in areas close to highways and industrial polluted areas, and 0.28% in less polluted areas.

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3）USA and China's Children Asthma Incident Rate Increase Year by Year, Even if Air Quality is Improved

USA:

- CHICAGO (Reuters) - About 25 million Americans, or 1 in 12 people, have asthma, a figure that is rising despite efforts to control key asthma triggers such as indoor smoking, U.S. government researchers said on Tuesday.
- According to the U.S. Centers for Disease Control and Prevention, an additional 4.3 million people were diagnosed with asthma from 2001 to 2009. The life-long disease causes wheezing, tightness in the chest, coughing and shortness of breath.
- "Despite the fact that outdoor air quality has improved, we've reduced two common asthma triggers - secondhand smoke and smoking in general -- asthma is increasing," Paul Garbe, chief of the CDC's Air Pollution and Respiratory Health Branch, said in a statement.
- Asthma diagnoses increased among all demographic groups between 2001 and 2009, but children were hit hardest, with asthma affecting 9.6 percent of children, compared with 7.7 percent of U.S. adults.

China:

It is learn that there is close to 300 million asthma patients, China has close to 30 million asthma patients, incident rate is between 1% to 4%, children below 16 years old have an even higher incident rate. [7] The national average level is 1.84%. [9]
According to the national epidemiology investigation on children, the asthma incident rate has increased 60% during the past 10 years. [6]

Beijing: In Beijing, the children asthma incident rate among 0-14 year age group has already exceeded 2%, meaning each middle school, primary school class on average has one asthma child. [6]

Nanjing: The Nanjing Children Hospital every ten years carries out sample survey on incidents of children asthma. Zhao De-yu told the journalist: "According to our investigation, in 2000 the incident of children asthma in the 0 – 14 age group was about 2.3%, by 2010 has exceeded 3%." Zhao is Director, Internal Medicine, Nanjing Children Hospital, as well as vice director of pediatric specialist, Pediatric Sub-division, Nanjing medical association. [7]
Zhao De-yu reported, the incident of asthma increases year by year. In 1990, the asthma incident in Nanjing was 1.4%, but by 2000 has almost doubled, reaching 2.3%. "Our Asthma outpatient service earlier received about 40 – 60 patients each morning. Since the past 1 – 2 years, each weekend morning could reach 200 patients."

Jinan: The journalist learnt at a number of hospitals during activities seeing patients on volunteer basis, due to environment and other factors, the incidents of children asthma has significantly increased compared with 10 years ago. [8]
On the "World Asthma Day" (2011-05-04) during activities seeing patients on volunteer basis, the Shandong Provincial Hospital and the Shangdong University Qilu Children's Hospital examined 164 children, and 46 of them were diagnosed with asthma.

Xiamen: According to the national epidemiology investigation on children in 2000, children's asthma incident rate in Xiamen is 3.96%, much higher than the national average level of 1.84%. [9]

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4）USA and China's Children with Chronic Diseases Rapidly Increase: The percentage of children with a current chronic disease rose to 25% in 2000-2006, the percentage of kids who had ever had a chronic illness grew to 52% in the same time in USA; In China, among children, youth and youngsters, incident rate of high blood pressure 9%, lipid disorders 9.8%; based on survey in a number of provinces and cities, the incident rate of pre-school age children with high blood pressure has already reached 2% - 4%, and for school children already 4% - 9%!

USA

- A follow-up study of 5,001 children from 1988 to 2006 and followed each child for six years, published by *Journal of the American Medical Association* in Feb. 2010 shows: More than half of children ages 8 to 14 have had a long-term health problem at some point, such as obesity, asthma, a learning disability or other ailment. [1] Though the percentage of children with a current chronic disease rose to 25% in 2000-2006, the percentage of kids who had ever had a chronic illness grew to 52% in the same time. [1-2]
- Much of the increase in chronic diseases was a result of obesity, says author Jeanne Van Cleave of the MassGeneral Hospital for Children in Boston.[1]
- In another study published in Academic Pediatrics, an estimated 43% of US children (32 million) currently have at least 1 of 20 chronic health conditions assessed, increasing to 54.1% when overweight, obesity, or being at risk for developmental delays are included. This tells us matters are much worse now–perhaps 50% are now chronically ill not counting obesity. [2]
- Furthermore, as this study is based on latest data 2007 data, 4 years old data, thus the situation in 2012 should be even worst![2]
- The study published by the June 2011 issue of Academic Pediatrics also said, developmental disability is on the rise in the U.S. Between 1997 and 2008, the number of school-age children diagnosed with autism, ADHD, or another developmental disability rose by about 17 percent. It also said roughly 15 percent of kids – nearly 10 million – have such a disability.[2-3]
- These rates will continue to increase, in view of one of the authors[2], since nothing is really changing in terms of the amount of unhealthy, industrially processed foods families and children eat, the poor USDA dietary guidelines being promoted as healthy, the very high rate of vaccinations and their damages inflicted, a continuing flow of pharmaceuticals, and of course, other environmental and lifestyle factors. So in five years we may be looking at 60-70% of American children being chronically ill and even more obesity and infertility.[1]
- A further study published by the Archives of Psychiatry in March and it found that the U.S. has the highest in the world lifetime rate of bipolar disorder at 4.4%, and India the lowest, with 0.1%, as reported by CNN. In other words, the U.S. has 44 times more bipolars (manic-depressives) than India. Bipolar disorder is characterized by cycles of depression and mania, a euphoric, high-energy state that can result in heightened levels of creativity or output as well as erratic or risky behavior. People with bipolar disorder are at high risk of substance abuse and suicide, and treatment includes psychiatric care and medication. [2]
- Boys had a higher prevalence overall and for a number of select disabilities compared with girls. Hispanic children had the lowest prevalence for a number of disabilities compared with non-Hispanic white and black children. Low income and public health insurance were associated with a higher prevalence of many disabilities. Prevalence of any developmental disability increased from 12.84% to 15.04% over 12 years., i.e. a 17% increase. Autism, attention deficit hyperactivity disorder, and other developmental delays increased, whereas hearing loss showed a significant decline. These trends were found in all of the sociodemographic subgroups, except for autism in non-Hispanic black children. [4-5]
- "We don't know for sure why the increase happened," study author Sheree Boulet of the Centers for Disease Control and Prevention, told Reuters. [4]
- But Philip Landrigan of the Mount Sinai School of Medicine in New York City, told USA Today that improvements in diagnosis can't fully explain the increase. Research suggests that environmental chemicals - including pesticides and the phthalates found in soft plastics - can affect kids' mental development, he said. [4]

China:

- The result of the recently announced "2010 China's Urban Health Survey" indicates, chronic disease incidents in China appear with a trend towards younger ages. Sanitation specialists suggest, should enhance guidance and interference to individual lifestyle. Mortality caused by chronic diseases accounts to 80% in China. As social pressure increases, medium-age and young people with chronic disease begins to increase, with a trend of which incident rates gradually increase year by year. Specialists consider, compared with infectious disease, the latent period of chronic disease is rather long, thus should give emphasis on prevention. [6]

- China carries out national resident nutrition and health condition survey every 10 years. According to the recent survey, obesity and overweight already become an outstanding health problem among urban children, youth and youngsters. The result of the 2005 national student corporeity and health survey also indicated, the obesity rate and overweight rate of urban boys 7 – 22 years age has already reached 13.25% and 11.39%, 1.4% and 2.7% respectively higher than 2000. [7]
- Yang Xiao-guang, researcher, China CDC, considers, it is estimated that the incidents of overweight and associated chronic diseases shall increase substantially during the next 10 – 20 years. If powerful interference actions are not adopted, the ratio of residents with normal body weight shall reduce from 70% at present to 1/3. [7]
- In China, within every 10 diabetes patient, one of them is a youth or youngster, with type 2 diabetes increasing most rapidly. Estimated accordingly, China already has close to 10 million youth and youngsters with diabetes. With Beijing as example, within the 6 – 18 year age group of urban and rural children and youngsters, the incident rate of diabetes is 0.57%; the incident rate of impaired fasting glucose (IFG) i.e. pre-diabetes, has already reached 1.35%. Since the 80s of the past century, the incident rate of diabetes in China almost doubles every 10 years. [8]
- The Beijing Health Bureau organized a number of hospitals to carry out an overall survey of overweight, high blood pressure, type 2 diabetes and lipid disorders among age group below 18 years. The result shows: Among children, youth and youngsters, incident rate of high blood pressure 9%, lipid disorders 9.8%. This means, within every 100 children there is about 9 children with high blood pressure, and about 10 children with dyslipidemia. And among children with diabetes, those with type 2 diabetes already accounted to 43%, compared with less than 5% 10 years ago. Specialist analysis, the overweight is the key for causing the increasing trend of these diseases. In Beijing, the rate of overweight among children, youth and youngsters, is already close to 10%, meaning a 47% increase since 2000. [9]
- Prof. Wang Wen, National Cardiovascular Center, Fuwai Hospital of China Academy of Medical Science, points out, based on survey in a number of provinces and cities, the incident rate of pre-school age children with high blood pressure has already reached 2% - 4%, and for school children already 4% - 9%, in which overweight children are majority. In USA and Japan, the incident rate for children respectively is 14.1% and 13.3%. High blood pressure is quietly stealing Children's health. [10]

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5）USA and China's Patients Reason Unclear Increase During Past Ten Years: 44% of Americans in 2005 had at least one chronic medical condition; Chinese residents with chronic disease is already 20%, the total number of determined diagnosed chronic patients reach 260 million. During past ten years, there are 10 million chronic disease patents newly diagnosed each year.

USA:

- Based on government survey data, 44 percent of Americans in 2005 had at least one chronic medical condition, which could include diabetes, high blood pressure, high cholesterol levels, cancer, arthritis, heart failure and others. That compares to 41 percent in 1996. The percentage of Americans with three or more chronic illnesses rose even more sharply, from 7 percent in 1996 to 13 percent in 2005. [1]

China:

- At the same time our nation's economy enjoys rapid development, we are also encountered by the heavy burden of chronic diseases, of which incidences is quickly increasing, and appearing among younger people. "During past ten years, the number of diagnosed chronic disease patients has increased 14.3%, which include diabetes increasing over three times, high blood pressure increasing over 1.5 times, cerebrovascular disease increasing one time, coronary heat disease increasing 63%, cancer increasing 60%." Result of the 4th National Sanitation Service General Survey show, the percentage of Chinese residents with chronic disease is already 20%, the total number of determined diagnosed chronic patients reach 260 million. During past ten years, there are 10 million chronic disease patents newly diagnosed each year. Chronic diseases account for the cause of 85% mortality, and 69% of the medical care financial burden. Chronic diseases bring substantial burden to family life, sanitation service system and public fiancé, especially have serious effect on the low income population, According to statistic, the percentage of chronic disease medical treatment cost within the total sanitation expenditures has already from 47.4% in 1990 increased to 70% in 2008, amounting to about RMB850 billion (approx. USD133 billion)，have already become a serious public sanitation problem and social problem. The WHO estimates, China's direct medical costs for chronic diseases by 2015 will exceed USD500 billion.
- Report "China Chronic Desease Report and New Developments in International Chronic Disease Prevention and Control" by Wang Shi-yong, Senior health specialist, World Bank China Office, revealed:
- Shi Xiao-ming, Chief, Chronic Disease Community Section, CDC, revealed: At present China has 305 million obese, 120 million overweight, 236 million high blood pressure, 32.92 million high cholesterin and 96.81 million diabetes patients.
- China's middle and old age people have on average 3.1 types of deseases.
- In April, 2011, the Ministry of Health issued The China Chronic Disease Report. The Report shows that the health of Chinese residents is facing serious challenge by chronic diseases. The first 4th causes of deaths are cerebrovascular disease, cancer, respiratory system disease and heart disease, all chronic disease. [2]
- Chronic disease is one of the greatest challenges to health of mankind. At the same time our nation's economy enjoys rapid development, we are also encountered by the heavy burden of chronic diseases, of which incidences is quickly increasing, and appearing among younger people. The number of already diagnosed chronic patients exceeds 260 million. Chronic diseases account for the cause of 85% mortality, and 69% of the medical care financial burden. Chronic diseases bring substantial burden to family life, sanitation service system and public fiancé, especially have serious effect on the low income population, have already become a serious public sanitation problem and social problem. [3]
- Li Lian-da, Academician, China Academy of Engineering, revealed: "During past ten years, the number of diagnosed chronic disease patients has increased 14.3%, which include diabetes increasing over three times, high blood pressure increasing over 1.5 times, cerebrovascular disease increasing one time, coronary heat disease increasing 63%, cancer increasing 60%." [4]
- Result of the 4th National Sanitation Service General Survey show, the percentage of Chinese residents with chronic disease is already 20%, the total number of determined diagnosed chronic patients reach 260 million. During past ten years, there are 10 million chronic disease patents newly diagnosed each year. Chronic disease already account as the cause of over 80% mortality.
- "In our nation, chronic disease already forms a major threat to public health." Kong Ling-zhi, Deputy Director, China CDC, says. According to statistic, the percentage of chronic disease medical treatment cost within the total sanitation expenditures has already from 47.4% in 1990 increased to 70% in 2008, amounting to about RMB850 billion (approx. USD133 billion).
- The WHO estimates, China's direct medical costs for chronic diseases by 2015 will exceed USD500 billion.

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6) 8.3% Americans Have Diabetes, 9.7% Chinese Have Diabetes Exceeding USA, the Risk is Very High for the "East Asian Weakling" Nightmare to Arrive Again for China!

USA：[1]

- Total prevalence of diabetes
- **Total:** 25.8 million children and adults in the United States—8.3% of the population—have diabetes.
- **Diagnosed:** 18.8 million people; **Undiagnosed:** 7.0 million people; **Prediabetes:** 79 million people*
- **New Cases:** 1.9 million new cases of diabetes are diagnosed in people aged 20 years and older in 2010.
- **Under 20 years of age**
- 215,000, or 0.26% of all people in this age group have diabetes
- About 1 in every 400 children and adolescents has diabetes
- **Age 20 years or older:** 25.6 million, or 11.3% of all people in this age group have diabetes
- **Age 65 years or older:** 10.9 million, or 26.9% of all people in this age group have diabetes
- **Men:** 13.0 million, or 11.8% of all men aged 20 years or older have diabetes
- **Women:** 12.6 million, or 10.8% of all women aged 20 years or older have diabetes
- **Race and ethnic differences in prevalence of diagnosed diabetes**
- After adjusting for population age differences, 2007-2009 national survey data for people diagnosed with diabetes, aged 20 years or older include the following prevalence by race/ethnicity: 7.1% of non-Hispanic whites; 8.4% of Asian Americans; 12.6% of non-Hispanic blacks; 11.8% of Hispanics
- Among Hispanics rates were: 7.6% for Cubans; 13.3% for Mexican Americans; 13.8% for Puerto Ricans

China:

In China, the rate of diabetes has increased ten fold during past 10 years, reached 9.7% at present, with about 150 million categorized under high risk of the illness! [2]

On 2011-11-24, Ji Li-nong, Director Committee Member of the Diabetes Sub-society of the China Medicine Society, at the No.15th national academic conference of the Diabetes Sub-society of the China Medicine Society (CDS2011) present the specialty speech. Ji Li-nong reported that **China's diabetes patient rate has doubled within the last decade, reached now 9.7%, making China the largest diabetes patient nation of the world, higher than the global average diabetes rate of 6.4%. At the same time, the diabetes high risk population is also expanding, about 150 million people at present.**

Shanghai's survey indicates: Diabetes patients in Shanghai during 2002 – 2009 rapidly increased 60%.

Xu Wanghong at el., Public Health College of Fudan University, jointly with Shanghai CDC, developed surveys of two groups of population which indicated, during 2002 – 2009, there was rapid increase in diabetes patients in Shanghai, diagnosed diabetes patients rose 45%, undiagnosed diabetes patients rose 13%. [3]

China becomes world's largest diabetes nation [4]

- China now has more people with diabetes than any other country, a new report shows, making it clear that the nation's soaring economic growth is taking a toll on public health.
- According to the report, more than 92 million adults in China have diabetes, and nearly 150 million more are well on their way to developing it. The disease is more common in people with large waistlines and in those who live in cities, the report indicates.
- The Federation projected last year that some 435 million people would have diabetes by 2030. "With this new study, we're going to have to rerun our estimate," Whiting told Reuters Health.
- The report, published Thursday in the New England Journal of Medicine, is based on

a nationally representative sample of more than 46,000 people who were tested for diabetes. [5]

- Based on their findings, the researchers calculate that about 50 million men and 42 million women have diabetes, or almost 1 in 10 adults. And in most cases, the disease is undiagnosed.
- The prevalence is twice as high as estimates suggested by previous studies, which did not use World Health Organization-recommended tests to diagnose diabetes, and is similar to US numbers. It would place China far ahead of India, whose estimated 50 million diabetics lands it a dubious second place in terms of the total number of people with diabetes.
- "These data really show diabetes has become a major epidemic in China," Dr. Jiang He, of Tulane University in New Orleans, told Reuters Health.
- **He, who worked on the new study with colleagues in China, noted that diabetes is a risk factor for heart disease, which is now the biggest killer in the country. "We basically need to make diabetes one of the top priorities for public health in China," he said.**

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7）About one in every 33 babies (about 3%) is born with a birth defect, including approx 1% diagnosed with congenital heart defects in USA; the incidence of newborns with defects in China at present is about 5.6%, the incidence of newborns with defects shows a trend of increase, increased from 877,000 in 1996 to 1.499 million in 2010, increase rate 70.9%, with congenital heart disease becomes the number one defect!

USA：

- In the United States, about one in every 33 babies (about 3%) is born with a birth defect. Birth defects are one of the leading causes of infant deaths, accounting for more than 20% of all infant deaths. [1]
- Congenital heart defects are diagnosed in approximately 1% of births in the United States and account for the largest proportion of infant mortality attributable to birth defects. [2]
- Congenital heart defects affect approximately 1% of live births, of which 25% are estimated to be critical and require surgery or catheterization within the first year of life.[3]
- In Michigan, the prevalence of CHDs reported by 1 year of age for whites increased slightly from about 99 cases per 10,000 live births in 1992 to about 135 cases per 10,000 live births in 2006, i.e. an increase of 36.36%. [4]
- Congenital heart defects (CHDs) account for 24% of infant deaths due to birth defects. In the United States, about 4,800 (or 11.6 per 10,000) babies born every year have one of seven *critical congenital heart defects* (CCHDs. [5]
- In 2003, congenital cardiovascular defects contributed only 0.5 percent of CVD deaths; however, they remain a leading cause of death in infants and children. Among children ages 5–11, data from the Bogalusa Heart Study have shown that 27.1 percent now have one or more risk factors for heart disease and that an additional 6.9 percent have two or more risk factors. Taken together, these epidemiological findings are great cause for alarm. [6]
- In the United States, hospital costs for people with a heart defect were about $1.4 billion in one year. Families and the government share the burden of these costs, which means that all taxpayers are affected. Other costs due to lost wages or work limitations can affect families and businesses as well.[7]
- CDC: The cause of most congenital heart defects is unknown. [7]

China:

- It is estimated that the incidence of newborns with defects in China at present is about 5.6%, the number of newborns each year is about 900,000, which includes about 25,000 newborns with clinical apparent defects at born. **[8]**
- During recent years, the incidence of newborns with defects shows a trend of increase, increased from 877,000 in 1996 to 1.499 million in 2010, increase rate 70.9%. In 2010, the first 5 types of defects of newborns identified by hospital

examination are congenital heart disease, many fingers (toe), total cleft lip, congenital hydrocephalus and a neural tube defects. The defects account for 49.1% of all defects of newborns, in which congenital heart disease becomes the number one defect. [9]

- The sequence of birth defects in the national infant deaths, ranked No.4 in 2000, which advanced to No.2 in 2011, reaching 19.1%. **[8]**
- In 2011, congenital heart defects account to 26.7% of all the newborns found with defects during monitoring. **[8]**
- During 2000 – 2011, the incidence of perinatal congenital heart disease is on the rise. In 2011, the average incidence of newborn congenital heart defects is 3.56 times of 2000, 4.41 times in urban areas, and 2.97 times in rural areas. **[7]**
- The national prevalence of perinatal birth defects decreased to 145.64 and 145.06 per 10,000 in 2012 and 2013 respectively, compared with 153.23 in 2011, meaning at least 16,000 fewer children with birth defects in the past two years, said Zhang Shikun, director of the commission's maternal and child health service bureau, at a press conference. [10]

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8) In USA, 78% increase of autism during 2007 - 2010, In China, autism rate in various areas has reached 1.5%, increased 10 times over 20 years, environmental, chemical, biological factors pointed as the culprit!

USA:

- CDC estimates (2010) 1 in 88 children (11.3 per 1,000) has been identified with an autism spectrum disorder (ASD). [1]
- This marks a 23% increase since our last report in 2009. And, a 78% increase since our first report in 2007. Some of the increase is due to the way children are identified, diagnosed and served in their local communities, although exactly how much is due to these factors in unknown. [1]
- ASDs are almost 5 times more common among boys (1 in 54) than among girls (1 in 252). [1]
- The largest increases over time were among Hispanic children (110%) and black children (91%). [1]
- California autism prevalence more than tripled from 1987 to 1998 [2]
- The California scientists "were at a loss to explain the reasons for what they called an epidemic of autism" in 2002 [2]
- "The causes of autism to be more environmentally influenced than previously

thought" – Findings by Canadian Scientists in 2012 [4]

- Published in the January 2009 issue of the journal Epidemiology, results from the study also suggest that research should shift from genetics to the host of chemicals and infectious microbes in the environment that are likely at the root of changes in the neurodevelopment of California's children. [5]
- "It's time to start looking for the environmental culprits responsible for the remarkable increase in the rate of autism in California," said UC Davis M.I.N.D. Institute researcher Irva Hertz-Picciotto, a professor of environmental and occupational health and epidemiology and an internationally respected autism researcher. [5]
- The incidence of autism by age six in California has increased from fewer than nine in 10,000 for children born in 1990 to more than 44 in 10,000 for children born in 2000. [5]

China:

- In China, there are now over 1 million children with autism, which is rapidly increasing, the autism rate in various areas has reached 1.5%, increased 10 times over 20 years! [6-7]
- Changchun: Autism prevalence rate 1.5% for children age 2 – 6 years [9]
- Harbin: Autism prevalence rate apparent increase trend, 2.27% for children age 2 – 6 years. [10]
- Shenzhen：Autism prevalence rate 1.32% for children, five folds of the national average rate 0.025%.[11]
- Nanjing: Autism rate of children have increased to 10 times within 20 years. "Specialists indicate, the fundamental reason causing autism is still not so clear at present, and there is not special effective drugs, early education is the main means of interference."[12]
- Shenyang: Children with autism have increased at the rate of 300 – 400 each year, indicating a trend of rapidly increasing! [13]
- Shanghai: Shanghai has over 8,000 autism patients, Children autism rate has reached 0.6% [14]

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9) Studies indicate possible links between Alzheimer's disease and Parkinson's disease, indicate 10% increase of annual incidence of Alzheimer's disease from 2000 to 2010 in USA; During the past 20 years (1998 - 2008), the average ages of Alzheimer's disease patients has advanced from 65 years to 55 years; In the USA, 50,000-60,000 new cases of Parkinson disease are diagnosed each year; Based on most conservative estimations, the incidence of Parkinson disease during recent 20 years in China has at least increased over 20 times!

USA:

- Studies Investigate Links Between Parkinson's Disease and Alzheimer's Disease
- Parkinson's disease (PD) and Alzheimer's disease (AD) are common neurodegenerative diseases associated with aging. People can develop both PD and AD, leading researchers to consider whether there are links between the two diseases. Two new studies have found that the two diseases do not appear to share genetic characteristics but may be linked by proteins. [1]
- In the genetics study, published in the August 5 online edition of *JAMA Neurology*, researchers analyzed genome-wide association (GWA) studies of PD and AD to look for genetic variants shared by both diseases. The study was led by author Valentina Moskvina, Ph.D., of the Cardiff University School of Medicine in Wales, in collaboration with an international team that included researchers from the National Institutes of Health. The team reviewed GWA studies of thousands of people with AD and PD, to see if any genetic variants increased the risk of both diseases. [2]
- The second study, published in the July 3 online edition of *Cell* by a team from the University of Pennsylvania led by Virginia Lee, Ph.D., investigated proteins found in AD and PD. Most neurodegenerative diseases are characterized by the accumulation of abnormal forms of certain proteins – for example, tau and amyloid in AD and alpha-synuclein in PD. Studies have shown some overlap in the pathology of AD and PD: more than 50 percent of people with AD show alpha-synuclein deposits and people with PD commonly have tau deposits. To better understand any relationship, researchers conducted experiments with alpha-synuclein involving mice and cell cultures.[3]

USA: Alzheimer's disease

- Alzheimer's disease is the most common type of dementia. "Dementia" is an umbrella term describing a variety of diseases and conditions that develop when nerve cells in the brain (called neurons) die or no longer function normally. The death or malfunction of neurons causes changes in one's memory, behavior and ability to think clearly. In Alzheimer's disease, these brain changes eventually impair an individual's ability to carry out such basic bodily functions as walking and swallowing. Alzheimer's disease is ultimately fatal. [4]
- An estimated 5.2 million Americans of all ages have Alzheimer's disease in 2013. This includes an estimated 5 million people age 65 and older [5], A1and approximately 200,000 individuals under age 65 who have younger-onset Alzheimer's. [6] [4]
- In 2000, there were an estimated 411,000 new cases of Alzheimer's disease. For 2010, that number was estimated to be 454,000 (a 10 percent increase); [4]
- By 2025, the number of people age 65 and older with Alzheimer's disease is estimated to reach 7.1 million — a 40 percent increase from the 5 million age 65 and older currently affected. [7]

USA: Parkinson's disease

- Parkinson's disease (PD) is a chronic and progressive movement disorder, meaning that symptoms continue and worsen over time. Parkinson's involves the malfunction and death of vital nerve cells in the brain, called neurons. Parkinson's primarily affects neurons in the an area of the brain called the substantia nigra. Some of these dying neurons produce dopamine, a chemical that sends messages to the part of the brain that controls movement and coordination. As PD progresses, the amount of dopamine produced in the brain decreases, leaving a person unable to control movement normally. [8]
- Parkinson's disease is the 14th leading cause of death in the United States, according to the Centers for Disease Control and Prevention's annual analysis of mortality data. The CDC also released data this week showing there was a 4.6% increase in deaths attributable to Parkinson's disease in 2010 (the most recent year for which they have data). [9] [10]
- Between 500,000 and 1.5 million Americans live with Parkinson's, a disease for which there is no cure or treatment to stop the progression. [9]
- Incidence of Parkinson's increases with age, but an estimated four percent of people with PD are diagnosed before the age of 50. [11]

- In the United States, 50,000-60,000 new cases of PD are diagnosed each year, adding to the one million people who currently have PD. [12]

China: **Alzheimer disease**

- According to a meta-analysis of 89 studies published June 7 in a China-themed issue of the Lancet, the number of people with dementia in the world's most populated country soared from 3.7 million in 1990 to 9.2 million in 2010. The figures eclipse those from the World Alzheimer Report 2012, which estimated 5.4 million dementia cases in China in 2010. Moreover, a report on global disease burden in the special Lancet issue found that the number of deaths in China due to Alzheimer's disease and other dementias doubled between 1990 and 2010, while mortality rates, especially among women, fell steeply during the same period. With continuing growth of China's aging population, these findings suggest the nation is heading for a bigger dementia burden than anticipated. [13] [14]
- The dementia study was led by senior investigators Wei Wang of Capital Medical University in Beijing, and Harry Campbell and Igor Rudan at the University of Edinburgh Medical School in the U.K. Christopher Murray of the University of Washington in Seattle led the analysis of China health trends with collaborators from China and Australia. [13] [14]
- A epidemiology survey report on Alzheimer's disease in Shanghai issued by public health departments show, prevalence of old aged older than 65 years old is 6%, above 80 years old exceeds 30%, prevalence of old aged above 65 years old increases at a rate of 1.4% per annum. [15]
- Survey data in Tianjin, Shanghai, Guangzhou and other large cities show: During the past 20 years (1998 - 2008), the average ages of Alzheimer's disease patients has advanced from 65 years to 55 years, i.e. "younger" 10 years. [16]

China: Parkinson disease

- During education activities in Shanghai on the "World Parkinson Day", Prof. Jiang Yu-ping, secretary, neurology committee of China Medical Society stated, the incidence of Parkinson disease during recent 20 years has at least increased over 20 times, such increase might be associated with environment and food factors. [16]
- Prof. Jiang said, based on the statistics of 1986, the incidence of Parkinson disease in China is about 0.047%, and according to Shanghai statistics of 2000, the incidence of Parkinson disease has reached 1.14%. However, national-wide statistics indicate incidence of Parkinson disease has reached about 2%. Based on most conservative estimations, the incidence of Parkinson disease during recent 20 years has at least increased over 20 times. [16]
- Date provided by the Shanghai Municipality Health Education Institute claims, Epidemiological statistics show that China at present (2007) has about 1.7 million Parkinson disease patients. [16]
- "Parkinson's disease is a kind of neurological system diseases, with higher incidence in older age. However, there is a trend of Parkinson disease developing in younger age patients. Before the diagnosed age was more over 70 years old, quite a number of Parkinson disease patients begin to appear in the 30 - 50 age group, it has become the 3rd killer of middle to older age people. [17]

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10) 1988-2004 USA incidence of primary liver cancer rapidly rose 90%, China's liver cancer patients accounts for 54.26% of World's total

USA:

- The incidence of primary liver cancer rose modestly between 1979 and 1988 (14.5 percent) and more rapidly subsequently (90 percent over the period 1988–2004) (Figure 1). Liver cancer was one of the most lethal digestive system cancers, although 5-year survival did increase nearly fourfold during this period, albeit to only 8 percent. [1]
- The number of new cases of hepatocellular carcinoma (HCC), a type of primary liver cancer, has increased in the U.S. over the past several years, reaching an incidence rate of 3.2 cases per 100,000 persons in 2006, according to the latest figures reported by the Centers for Disease Control and Prevention (CDC) in the May 7, 2010 issue of Morbidity and Mortality Weekly Report. [2]

China:

- At present, cancer prevalence in China is 285.91/100,000, on average every minute everyday 6 persons are diagnosed with malignant cancer. [3]
- Supervision data shows, colon cancer rises faster in the urban areas, as well as thyroid cancer. At present, in urban areas, the prevalence of thyroid cancer already ranks No.4. [3]
- National cancer mortality rates has reached 180.54/100,000, reaching 2.7 million deaths caused cancer ear year. The national rate of mortality caused by cancer in China is 13%, meaning cancer causes one of every 7 - 8 deaths. [3]
- The mortality rate of men caused by cancer is higher than women, with ratio of 1.68/1. [3]
- Regarding kinds of cancer, lung cancer ranks No.1, followed by stomach cancer, then colon cancer, liver cancer and then esophageal cancer. The top ten kinds of cancer amount to 76.39% of all kinds of cancer. [3]
- The cancer with highest mortality rate still is lung cancer, followed by liver cancer, stomach cancer, esophageal cancer and colon cancer. [3]
- Lung cancer has the highest mortality rate in both men and women. The kinds of death causing cancer in men then include liver cancer, stomach cancer, esophageal cancer and colon cancer. In women then include stomach cancer, liver cancer, colon cancer and breast cancer. [3]
- Primary liver cancer in our country is one of the common malignant tumors. Has high mortality rate, ranking No.3 following malignant tumor in the stomach and in the esophagus; but, in the rural areas ranking 2nd place following cancer in the stomach. In China, about 110,000 people die from liver cancer each year, accounting 45% of the total number of deaths caused by liver cancer worldwide. [4]
- China's liver cancer situation is very grim, in 2000 306,000 patients developed liver cancer, and 306,000 mortalities from liver cancer, which accounted for 54.26% of

world liver cancer patients, and 54.64% of all mortalities caused by liver cancer over the world. [5]

- In characteristic of regional distribution of liver cancer in China is higher incidents in coastal regions than inland regions; higher incidents in Southeast and Northeast regions than Northwest, North and Southwest regions of China, and higher incidents in coastal islands and river estuaries regions. [5]
- According to cancer register data 1998-2002 from nationwide 30 cities and counties, China's top three liver cancer areas for men are Qidong of Jiangsu Province, Haimen of Jiangsu Province, and Fushui of Guangxi Autonomous Region, and top three liver cancer areas for female are Qidong of Jiangsu Province, Haimen of Jiangsu Province, and Yanting of Sichuan Province. [5]
- From 1972 to 1999, although the total number of liver cancer patients in Shanghai increased significantly, but age standardized incidence rate reduced, for male and female reduced 26% and 28% respectively. [5]
- In 2006, the Ministry of Health and Ministry of Science & Technology led a national survey on nationwide mortality causes. The Department of Health of the Guangxi Autonomous Region entrusted the Cancer Hospital attached to the Guangxi Medical University to carry out review mortality causes from 9 locations. Survey data indicate, the first 3 causes of death of population in Guangxi respectively are malignancy cancers, respiration system diseases and cerebrovascular disease. During the 70s of the last century, the mortality rate caused by malignancy cancers was 38.29/100,000, during the 90s was 80.48/100,000, and at present is 112.0/100,000, indicating apparent increase. [6]
- The mortality rate of 112.0/100,000, to the over 50 million population of Guangxi means about 50,000 people die from malignancy cancers, the prevalence increase ranks No.1 in China, which makes Guangxi one of the regions with the highest liver cancer and nasopharynx prevalence rate in China. [6]
- 370,000 new liver cancer patients and 536,000 new lung cancer patients appear each year, which is increasing at the pace of 5% each year in China. [6]
- Epidemiology investigation indicates: The liver cancer incidence for males are 26.23/100,000, and for females 11.09/100,000 in Tianjin. [7]

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11) Children cancer increasing, especially leukemias, dramatically increased in USA and China.

USA:

About 12,500 children and adolescents under the age of 20 years are diagnosed with cancer each year. Childhood cancers remain a leading cause of childhood deaths in the United States, despite the fact that advances in health care and treatment have dramatically increased survival from these cancers. [1]

The most common childhood cancers are leukemias, cancers of the blood cells. There are different kinds of childhood leukemia. The most common kinds are acute lymphocytic leukemia (ALL) and acute myelogenous leukemia (AML). Brain and other nervous system cancers are the second most common types of childhood cancers. Of the 12 major types of childhood cancer, leukemias and brain and other nervous system cancers account for 40% of all cases among children less than 20 years of age. Other childhood cancers, in decreasing order of occurrence, include lymphomas, sympathetic nervous system

cancers, soft tissue sarcomas, renal tumors (Wilms tumor and renal carcinoma), bone tumors (osteosarcoma and Ewing sarcoma), malignant germ cell tumors, retinoblastomas, hepatic tumors, and other malignancies. Researchers have studied childhood cancers for many years but still do not know a lot about what causes them. Finding the causes of childhood cancers is challenging because cancer in children is rare and each type of cancer may have different factors that lead to its development. It is especially difficult to identify environmental factors related to childhood cancer because environmental exposures to the parent, the child in the womb, or the child after birth may play a role. Childhood cancers, like adult cancers, may be the result of a mix of genetic, environmental, and behavioral causes, not just one factor by itself. [1]

China:

Tumor prevalence in Children shows tread of increase, on average there is one child tumor patient among ever 10,000 children. The causes of death among children deaths under 14 years old, malignant tumor already ranks No.2. Among all kinds of children tumors, leukemia, brain tumor, malignant lymphoma and neuroblastoma rank the top four, leukemia accounts to 1/3 of all children tumor patients. [2]

Based on survey in a number of cities, the incidence of children tumor each year is 10 per each 100,000. China has about 400 million children, thus new children tumor incidence could reach over 30,000 children. [2]

The increasing trend of children malignant tumors is apparent, with a higher rate in boys than girls. Two age peaks are apparent, 42% develop tumors before 3 years old, thereafter with a lower rate, the 2nd peak appears during period of puberty. [2]

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12) Inflammatory Bowel Diseases rapidly increased 65 percent increase from 2000 to 2009, and increased 12 times in Shanghai from 2003 to 2013!

USA

- Inflammatory Bowel Diseases (IBD) is a broad term that describes conditions with chronic or recurring immune response and inflammation of the gastrointestinal tract. The two most common inflammatory bowel diseases are ulcerative colitis and Crohn's disease. [1]
- Both illnesses have one strong feature in common. They are marked by an abnormal response by the body's immune system. Normally, the immune cells protect the body from infection. In people with IBD, however, the immune system mistakes food, bacteria, and other materials in the intestine for foreign substances and it attacks the cells of the intestines. In the process, the body sends white blood cells into the lining of the intestines where they produce chronic inflammation. When this happens, the patient experiences the symptoms of IBD. [1]
- The peak age of onset for IBD is 15 to 30 years old, although it may occur at any age. About 10% of cases occur in individuals younger than 18 years. [1]
- CDC claims: Precise incidence and prevalence of Crohn's disease and ulcerative colitis have been limited by (1) a lack of gold standard criteria for diagnosis; (2) inconsistent case ascertainment; and (3) disease misclassification. The data that does exist suggest that the worldwide incidence rate of ulcerative colitis varies greatly between 0.5–24.5/100,000 persons, while that of Crohn's disease varies between 0.1–16/100,000 persons worldwide, with the prevalence rate of IBD reaching up to 396/100,000 persons. It is estimated that as many as 1.4 million persons in the United States suffer from these diseases. [1]
- A new study found, the largest investigation to date has found a dramatic increase in the number of hospitalizations for children with inflammatory bowel disease (IBD) during the past decade in the United States. [2]
- The new study, published online and scheduled for the August 2013 print issue of the Journal of Investigative Medicine, found a 65 percent increase in IBD hospital discharges from 2000 to 2009. The number increased from 11,928 discharges in 2000 to 19,568 discharges in 2009. [2]

China:

- During past 10 years (2003 - 2013), the incidence of inflammatory Bowel Disease in children below 14 years old increased 12 times. [3]
- A study published in Aug. 2013 by Inflammatory Bowel Disease Previously confirms: A disease of the West and rarely seen in China, inflammatory bowel disease (IBD) is now increasing in incidence in China. However, its true incidence is unknown. Conclusion: There is a substantial incidence of IBD in China.[4]

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13) Sudden cardiac arrest (SCA) increasing, including in younger people in both USA and China.

USA
CDC confirms:

- About 600,000 people die of heart disease in the United States every year–that's 1 in every 4 deaths. [1]
- Heart disease is the leading cause of death for both men and women. More than half of the deaths due to heart disease in 2009 were in men. [1]
- Coronary heart disease is the most common type of heart disease, killing nearly 380,000 people annually. [1]
- Every year about 720,000 Americans have a heart attack. Of these, 515,000 are a first heart attack and 205,000 happen in people who have already had a heart attack.[2]

The Pediatric Sudden Cardiac Arrest report issued in 2012 by American Academy of Pediatrics reports: [3]

- CDC has estimated that every year in the United States, approximately 2000 patients younger than 25 years will die of SCA. [4]
- Other older reports estimate the frequency of SCA in children and adolescents to be between 0.8 and 6.2 per 100 000 per year. [5] [6] [7] [8] [9]
- Two studies suggest that the frequency of SCA in adolescents and young adults actually may be increasing. [10] One study published in 2003 estimated Sudden cardiac deaths rise 10% in young Americans. [11]

China:

- The number of sudden cardiac arrest deaths reach 544,000 each year, i.e. over 1000 people die of SCA each day, with higher incidence in male than female. [12]
- According to media reports, in 1998 the "120" Emergency Center in Beijing received over 80 sudden cardiac arrest death young to middle age patients, this number rapidly increased to over 270 in 2011. [13]
- Other media reported, the percentage of sudden cardiac arrest deaths at age lower than 50 years old reached 12.65%, increased 1.7% compared with 1998. [13]
- During the 1st quarter of 2013, the "120" Emergency Center in Qingdao registered 848 sudden cardiac arrest deaths, the age of most of them were between 35 - 59 years old, accounting to 25% - 35% of the total visits by the center. [14]

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[13] Sina Health, Why does sudden death catch on young people, 2012-07-19
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Common in both USA and China: Exposure to glyphosate and n-hexane residues through environment pollution, food and chemical extracted food oil

China:

- **Largest producer of glyphosate of the world.**
- **Largest exporter of glyphosate of the world, including export of glyphosate to Monsanto to produce Roundup formula herbicide.**
- **Massive environment pollution caused by illegal discharge of toxic industrial waste from production of glyphosate.**
- **China is major importer of Monsanto's Roundup, which accounts to 80% of China's herbicide market.**
- **China widely applies Roundup and other glyphosate-based herbicide, causing widespread pollution.**
- **China is largest importer of RR soybeans, RR canola processed into RR soybean food oil and RR canola food oil, flooding the Chinese market**
- **Chinese researchers identified AMPA, metabolites of glyphosate, toxic, in RR soybean food oil.**
- **RR soybean protein powder, containing higher levels of glyphostate, is added to sausages, ham, frozen food, cakes, cookies, bread, even infant formula milk powder and wheat-flour in China.**
- **About 90% of food oil in China, are produced by chemical extraction, using n-hexane as oil extracting solvent, results most food oil contains n-hexane residue, including food oil process from soybeans, canola, corn, rice husks.**
- **Most soybean protein powder in China is processed from soybean cake, the side product of chemical extracted soybean oil.**
- **According to Chinese national standards, up to <50 mg/kg n-hexane residue is allowed in food oil, and up to <500 mg/kg n-hexane residue is allowed in food grade soybean protein powder added to infant formula milk powder.**
- **"EFSA allows chemical extracted RR soybean food oil and soybean protein powder to be added to infant formula milk powder", is the main reason China's Food & Drug Administration Bureau allows such criminal practice!**

Eleven studies by Chinese scholars reveal harm caused by glyphosate

Eleven scientific studies by Chinese scholars reveal that glyphosate cause damage to proteins and lipids, cause apoptosis and necrosis of liver cells with obvious damage, cause mutagenic and reproductive toxicity, capable of causing birth defects to human offspring.

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Twenty-four international and Chinese and scientific studies and epidemiology studies prove that hexane residuals and benzene residuals cause reproduction toxicity to both female and males

Summary:

- Hexane residuals were found in urine of fathers, mothers and children exposed to application or mixture of glyphosate-based herbicide Roundup, meaning that glyphosate can enter blood circulation of males, females and children.
- Hexane residuals are found can through blood circulation can pass through the placenta and enter into fetus of pregnant rats.
- Hexane is a hormone interrupter, which demonstrates effects harmful to human health at very low dose levels, even by exposure of breathing air with low levels of hexane content.
- Hexane, as well as benzene, i.e. residual contained in hexane solvent produced for vegetable food oil extraction, show that they specifically attack and cause damage to the female reproduction system, as well as attack and cause damage to the male reproduction system and sperms.

[Note: Benzene is a residue of the hexane solvent used for vegetable oil extraction, thus is studied together with the effects of hexane.]

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F. Angelini Research Institute, Viale Amelia 70, 00181, Rome, Italy
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Hindawi Publishing Corporation
BioMed Research International
Volume 2014, Article ID 179691, 8 pages
http://dx.doi.org/10.1155/2014/179691

Research Article

Major Pesticides Are More Toxic to Human Cells Than Their Declared Active Principles

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Received 28 October 2013; Accepted 11 December 2013; Published 26 February 2014

Academic Editor: Bruno C. Cavalcanti

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Pesticides are used throughout the world as mixtures called formulations. They contain adjuvants, which are often kept confidential and are called inerts by the manufacturing companies, plus a declared active principle, which is usually tested alone. We tested the toxicity of 9 pesticides, comparing active principles and their formulations, on three human cell lines (HepG2, HEK293, and JEG3). Glyphosate, isoproturon, fluroxypyr, pirimicarb, imidacloprid, acetamiprid, tebuconazole, epoxiconazole, and prochloraz constitute, respectively, the active principles of 3 major herbicides, 3 insecticides, and 3 fungicides. We measured mitochondrial activities, membrane degradations, and caspases 3/7 activities. Fungicides were the most toxic from concentrations 300–600 times lower than agricultural dilutions, followed by herbicides and then insecticides, with very similar profiles in all cell types. Despite its relatively benign reputation, Roundup was among the most toxic herbicides and insecticides tested. Most importantly, 8 formulations out of 9 were up to one thousand times more toxic than their active principles. Our results challenge the relevance of the acceptable daily intake for pesticides because this norm is calculated from the toxicity of the active principle alone. Chronic tests on pesticides may not reflect relevant environmental exposures if only one ingredient of these mixtures is tested alone.

1. Introduction

Pesticides are used throughout the world as mixtures called formulations. They contain adjuvants, which are often kept confidential and are called inerts by the manufacturing companies, plus a declared active principle (AP), which is the only one tested in the longest toxicological regulatory tests performed on mammals. This allows the calculation of the acceptable daily intake (ADI)—the level of exposure that is claimed to be safe for humans over the long term—and justifies the presence of residues of these pesticides at "admissible" levels in the environment and organisms. Only the AP and one metabolite are used as markers, but this does not exclude the presence of adjuvants, which are cell penetrants. Our previous investigation showed unexpected APs for human cell toxicity in the adjuvants of glyphosate-based herbicides [1]. Ethoxylated adjuvants found in glyphosate-based herbicides were up to 10.000 times more toxic than the so-called active AP glyphosate [1] and are better candidates for secondary side effects. This may explain in vivo long-term toxicity from 0.1 ppb of the formulation and other toxicities that were not explained by a consideration of glyphosate alone [2–5]. These adjuvants also have serious consequences to the health of humans and rats in acute exposures [6, 7]. These findings prompted us to investigate the presence of similar toxic molecules in other classes of pesticides.

The regulatory system assumes that the AP designed to specifically target plants, insects or fungi is the most toxic compound of a formulation to nontarget species. Thus long-term regulatory tests are performed on this substance alone. In this paper, we tested to what extent the AP or adjuvants in present formulations account for the toxicity of 9 major pesticides: 3 herbicides, 3 insecticides, and 3 fungicides.

We have thus selected 9 APs of herbicides, insecticides, or fungicides of different classes (Table 1) used for agricultural or domestic purposes, from the major pesticides

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Table 1: Summary of the pesticides tested. We have tested 9 APs of major herbicides, insecticides, or fungicides of different classes, used worldwide for agricultural or domestic purposes. Concentrations of the APs are indicated in parenthesis. Adjuvants are reported where they are mentioned on the material safety data sheet (MSDS).

	Pesticide classes	Active principles	(g/L)	Formulations	Declared adjuvants
Herbicides	Phosphonoglycine	Glyphosate	450	Roundup GT+	Ethoxylated etheralkylamine
	Phenylurea	Isoproturon	500	Matin EL	Unknown
	Synthetic auxin	Fluroxypyr (ester 1-methylheptyl)	200	Starane 200	Solvent naphtha; alkyl-aryl sulfonates
Insecticides	Carbamate	Pirimicarb	500	Pirimor G	Docusate sodium; benzenesulfonic acid
	Neonicotinoid	Imidacloprid	200	Confidor	1-Methyl-2-pyrrolidinone
	Neonicotinoid	Acetamiprid	5	Polysect Ultra	1,2-Benzisothiazoline-3-one; ethanol
Fungicides	Triazole	Tebuconazole	250	Maronee	N,N-Dimethyldecanamide
	Triazole	Epoxiconazole	125	Opus	Solvent naphtha; fatty alcohol ethoxylated
	Imidazole	Prochloraz	450	Eyetak	Solvent naphtha; xylene; isobutanol

used worldwide [8, 9]. First we tested Roundup and its AP, glyphosate. Upon the introduction of herbicide tolerant genetically modified organisms (GMOs), designed to tolerate Roundup and to accumulate unusual levels of its residues, Roundup quickly became the major pesticide in the world and a major food or feed contaminant [10]. Two other herbicides of a different class were tested: isoproturon (phenylurea) is the second most widely used AP of herbicides in Europe in the control of annual grasses and broad-leaved weeds in cereals and a major water contaminant [11]; and fluroxypyr (a synthetic auxin) is used as an AP on noncrop areas and also for agricultural use on wheat, barley, corn, and oats. Forest services are expanding its use as an alternative to other pesticides known to be toxic [12]. However, it is poorly studied and its effects on human cells were never published before. Among the insecticides chosen, pirimicarb (a carbamate), used specifically to target aphids, is the most representative AP in this family for cereal production and garden insect control worldwide [13]. Neonicotinoids are the largest selling insecticides worldwide and are marketed in more than 120 countries for use on more than 140 crops [14]. Their spectrum of biological efficacy covers a broad range of target pests such as whiteflies, lepidopteran, and coleopteran species. We tested the major neonicotinoid, the AP imidacloprid, which is widely used for seed dressing. Its toxicity against bees is widely admitted [15], but little is known about the effects of its adjuvants. We also tested the AP acetamiprid, another neonicotinoid advocated to replace imidacloprid [16]. Azole-type fungicides are applied every year on field crops, fruit trees, vegetables, and grassgrowing areas [17]. We tested the two most popular triazole APs, epoxiconazole and tebuconazole. Finally, prochloraz (imidazole) was tested because it is the main fungicide sprayed on cereals in Europe [8].

We used the embryonic (HEK293), placental (JEG3), and hepatic (HepG2) human cell lines because they are well characterized and validated as useful models to test toxicities of pesticides [18–20], corresponding to what is observed on fresh tissue or primary cells [21–23]. These cell lines are even in some instances less sensitive than primary cells [24, 25] and therefore do not overestimate cellular toxicity. We assayed their mitochondrial succinate dehydrogenase (SD) activity (MTT assay) after 24 h pesticide exposure, which is one of the most accurate cytotoxicity assays for measuring the toxicity of pesticide adjuvants such as surfactants [26]. Cytotoxicity was confirmed by the measurement of apoptosis and necrosis, respectively, by caspases 3/7 activation [27] and adenylate kinase leakage after membrane alterations [28]. Each AP was tested from levels below its ADI to its solubility limit in our system. The formulations containing adjuvants were tested at the same levels.

2. Materials and Methods

2.1. Chemicals. The 9 Aps, glyphosate (N-phosphonomethyl glycine, G, CAS: 1071-83-6), isoproturon (3-(4-isopropylphenyl)-1,1-dimethylurea, CAS: 34123-59-6), fluroxypyr 1-methylheptyl ester (((4-Amino-3,5-dichloro-6-fluoro-2-pyridinyl)oxy)acetic acid, 1-methylheptyl ester, CAS: 81406-37-3), acetamiprid (N-[(6-chloro-3-pyridyl) methyl]-N′-cyano-N-methyl-acetamidine, CAS: 135410-20-7), imidacloprid (1-((6-chloro-3-pyridinyl)methyl)-4,5-dihydro-N-nitro-1H-imidazol-2-amine, CAS: 105827-78-9), pirimicarb (2-dimethylamino-5,6-dimethyl-4-pyrimidinyl dimethylcarbamate, CAS: 23103-98-2), prochloraz (N-propyl-N-(2,4,6-trichlorophenoxy) ethyl-imidazole-1-carboxamide, CAS: 67747-09-5), epoxiconazole (1-{[3-(2-Chlorophenyl)-2-(4-fluorophenyl)-2-oxiranyl]methyl}-1H-1,2,4-triazole, CAS: 135319-73-2), tebuconazole (1-(4-Chlorophenyl)-4,4-dimethyl-3-(1,2,4-triazole-1-ylmethyl)pentane-3-ol, CAS: 107534-96-3), and 3-(4,5-Dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide (MTT), as well as all other compounds, unless otherwise noted, were obtained from Sigma-Aldrich. Formulations were available on the market: Roundup GT+ (approval 2020448), Matin EL (2020328), Starane 200 (8400600), Pirimor G (7500569), Confidor (9200543), Polysect Ultra SL (2080018), Maronee (2000420), Opus (9200018), and Eyetak (9400555). MTT was prepared as a 5 mg/mL stock solution in phosphate-buffered saline, filtered through a 0.22 μm filter before use, and diluted to 1 mg/mL in a serum-free medium.

2.2. Cell Lines and Treatments. The human embryonic kidney 293 cell line (HEK 293, ECACC 85120602) was provided by Sigma-Aldrich (Saint-Quentin Fallavier, France). The hepatoma cell line HepG2 was provided by ECACC

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(85011430). JEG3 cell line (ECACC 92120308) was provided by CERDIC (Sophia-Antipolis, France). Cells were grown in phenol red-free EMEM (Abcys, Paris, France) containing 2 mM glutamine, 1% nonessential amino acid, 100 U/mL of antibiotics (a mixture of penicillin, streptomycin, and fungizone) (Lonza, Saint Beauzire, France), 10 mg/mL of liquid kanamycin (Dominique Dutscher, Brumath, France), and 10% Fetal Bovine Serum (PAA, les Mureaux, France). JEG3 cells were supplemented with 1 mM sodium pyruvate. Cells were grown with this medium at 37°C (5% CO_2, 95% air) during 48 h to 80% confluence, then washed, and exposed 24 h with serum-free EMEM to the APs or the formulations. Before treatment, all the pesticides were solubilized in a 100% DMSO solution, then diluted in serum-free medium to reach 0.5% DMSO (which had been previously proven not to be cytotoxic for the cells), and adjusted to a similar pH. This model was validated [29] and cytotoxic effects were similar in presence of serum but delayed by 48 h.

2.3. Cytotoxicity Measurement. After treatments, succinate dehydrogenase (SD) activity assay (MTT) [30] was applied as described previously [25]. Integrity of mitochondrial dehydrogenase enzymes indirectly reflects the cellular mitochondrial respiration. The optical density was measured at 570 nm using a Mithras LB 940 luminometer (Berthold, Thoiry, France). The bioluminescent ToxiLight bioassay (Lonza, Saint Beauzire, France) was applied for the membrane degradation assessment, by the intracellular adenylate kinase (AK) release in the medium; this is described as a necrosis marker [28]. Finally, the apoptotic cell death was evaluated with the Caspase-Glo 3/7 assay (Promega, Paris, France). Luminescence was measured using a Mithras LB 940 luminometer (Berthold, Thoiry, France). These methods were previously described [25].

2.4. Statistical Analysis. The experiments were repeated at least 3 times in different weeks on 3 independent cultures ($n = 9$). All data were presented as the means ± standard errors (SEMs). LC50 values were the best-fitted value of a nonlinear regression using sigmoid (5-parameter) equation with the GraphPad Prism 5 software. The differential effects between APs and formulations are measured by the surfaces between the curves by the calculation of integrals with ImageJ software [31]. Statistical differences of necrosis and apoptosis assays were calculated by a nonparametric Mann-Whitney test with the GraphPad Prism 5 software.

3. Results

All formulations were cytotoxic and far more toxic than their APs, except for isoproturon and its formulated pesticide Matin which were both not soluble over 100 ppm. As a matter of fact, Matin does not have any declared adjuvant (Table 1). On human cells, among the tested products, fungicides were the most toxic (Figure 1), being cytotoxic from doses 300–600 times lower than agricultural dilutions, followed by herbicides (Figure 2) (except Matin) and then insecticides (Figure 3). JEG3 was the most sensitive cell line, the LC50 being on average, respectively, 7% and 23% lower than for HEK293 and HepG2, the least sensitive. The LC50 is calculated over 24 h. In all cell types, fungicides were the most toxic (mean LC50 12 ppm). They were followed by the herbicide Roundup (LC50 63 ppm), twice as toxic as Starane, and more than 10 times as toxic as the 3 insecticides, which represent the less toxic group (mean LC50 720 ppm). The APs of fungicides were the only APs that were toxic alone in our system, from 50 ppm in JEG3 for prochloraz, but they were still less toxic than their formulations.

In fact, 8 formulations out of 9 were clearly on average several hundred times more toxic than their APs, ranging from 2-3 times more toxic for pirimicarb or prochloraz to 1056 times more toxic for tebuconazole. Results were similar for all cell types.

This was even better understood by the differential measurement of the cytotoxicity through membrane disruption (Figure 4) or caspases activation (Figure 5). For the three cell lines, membrane disruptions are comparable. Most of the pesticides were necrotic and more necrotic than their APs except for Eyetak whose active principle prochloraz is the main toxicant of the formulation. We have not obtained relevant results with Pirimor because a green dye in the formulated product prevents the lecture of luminescence. Differential effects on apoptosis (Figure 5) were less obvious. With the formulated herbicides and insecticides, apoptosis levels are mostly decreased because of the prevailing effects of necrosis. This is not the case with fungicides which are apoptotic depending on the cell line. JEG3 cell lines are the most sensitive to apoptosis, in particular with fluroxypyr, pirimicarb, tebuconazole, and prochloraz. Overall, adjuvants in pesticides are thus far from inerts but cell membrane disruptors and induce in addition mitochondrial alterations.

4. Discussion

This is the first time that all these formulated pesticides have been tested on human cells well below agricultural dilutions. The three different cell types reacted very similarly and the toxicities were observed on several biomarkers; this confirmed our results. Moreover, these are very consistent with several studies on cell lines [1, 25], where placental JEG3 cells were found to be the most sensitive. In this study [1], adjuvants were also more cytotoxic through the disruption of membrane and mitochondrial respiration than from an activation of apoptotic pathways. Primary cells are in some case up to 100 times more sensitive, for instance, neonate umbilical cord vein cells [25]. We also study here short exposures (24 h), but we have previously demonstrated a time-amplifying effect: the differential toxicity between the AP glyphosate and Roundup is increased by 5 times in 72 h [29]. It appears that, with cell lines and short exposures, we underestimate by far the direct toxicity of the products in the long term. In this case in vivo, the metabolism may reduce the toxic effect, but this can be compensated or amplified by bioaccumulation and/or the combined effect of the AP with adjuvants. For instance, in this experiment, after 24 h, 63 ppm of Roundup was found to be toxic to cells, but in our previous

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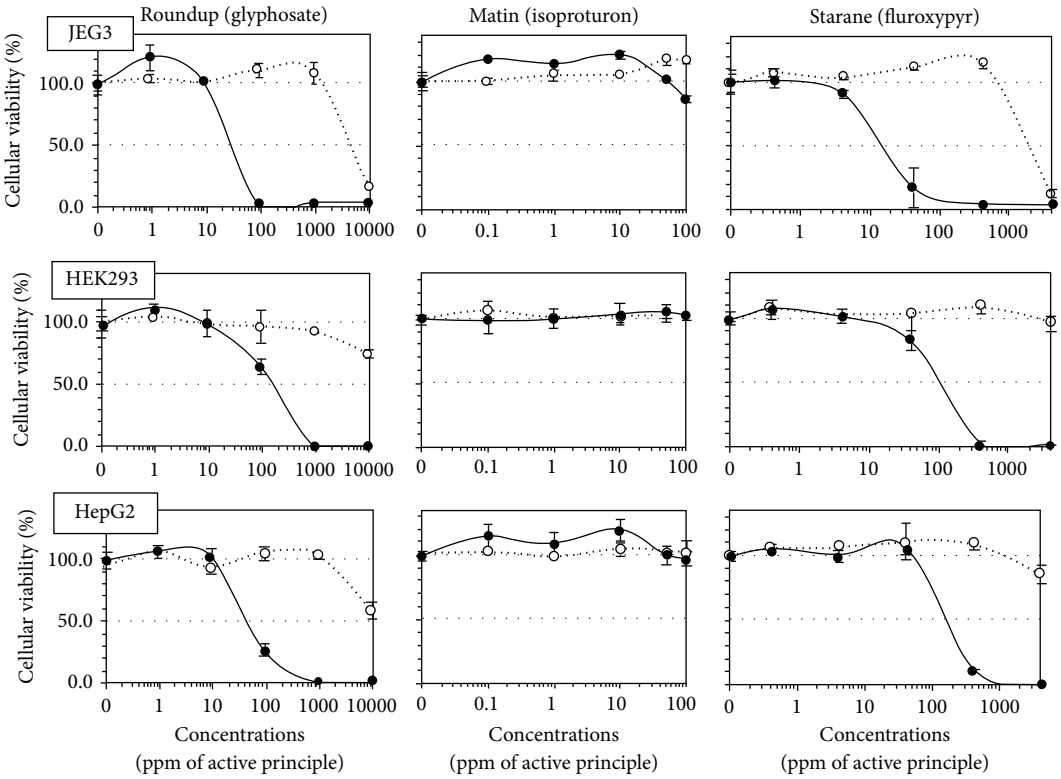

Figure 1: Differential cytotoxic effects between formulations of herbicides and their active principles (APs) on HepG2, HEK293, and JEG3 human cell lines. Effects on the mitochondrial succinate dehydrogenase (SD) activity, reflecting cell respiration inhibition, were measured in percentage of control in serum-free medium after 24 h of exposure. The concentrations in ppm are dilutions of each AP (dotted line) and their equivalent in formulation with adjuvants (solid line). All formulations are more toxic than their APs, except for isoproturon. SEMs are shown in all instances ($n = 9$).

experiment, after two years in rats, only 0.1 ppb of Roundup was found to be sufficient to provoke pathologies [2].

Adjuvants in pesticides are generally declared as inerts, and for this reason they are not tested in long-term regulatory experiments. It is thus very surprising that they amplify up to 1000 times the toxicity of their APs in 100% of the cases where they are indicated to be present by the manufacturer (Table 1). In fact, the differential toxicity between formulations of pesticides and their APs now appears to be a general feature of pesticides toxicology. As we have seen, the role of adjuvants is to increase AP solubility and to protect it from degradation, increasing its half-life, helping cell penetration, and thus enhancing its pesticidal activity [32] and consequently side effects. They can even add their own toxicity [1]. The definition of adjuvants as "inerts" is thus nonsense; even if the US Environmental Protection Agency has recently changed the appellation for "other ingredients," pesticide adjuvants should be considered as toxic "active" compounds.

In the scientific literature, in contrast with regulatory beliefs, some harmful effects of the adjuvants present in this study are reported. In the formulations (Table 1) Starane 200, Opus, and Eyetak, the adjuvants include solvent naphtha (a petroleum distillate), which is known to have developmental effects in rodents [33]. Xylene (in Eyetak) has long been associated with cardiac and central nervous system diseases in humans [34]. 1-Methyl-2-pyrrolidinone (in Confidor) is a developmental toxicant and caused malformations, incomplete ossification of skull, and decreased fetal body weights in rats [35]. N,N-Dimethyldecanamide (Maronee adjuvant) has been characterized as a developmental toxicant in rodents [36] but is insufficiently studied for reproductive toxicity. The distinction between AP and "declared inert" compounds appears to be a regulatory assumption with no toxicological basis, from this experiment and others. Even industry and regulators contradict themselves in the classification of APs and inert compounds. For example, 1,2-benzisothiazoline-3-one is classed as an inert ingredient in the pesticide Polysect in particular and as an active ingredient in cleaning products [37].

All this does not exclude the toxicity of APs alone. Glyphosate inserted in the aromatase active site of mammalian cells disrupts steroidogenesis [23]. Imidacloprid alters the developing immunity in rats [38]. Fluroxypyr (ester 1-methylheptyl) has never been tested in human cells before this study but appears to be toxic from 22 ppm in formulation; its ADI is only 0.8 ppm/day (DG SANCO, 2013). It also appears here that prochloraz is the main toxicant of the tested formulation.

It is commonly believed that Roundup is among the safest pesticides. This idea is spread by manufacturers, mostly in the reviews they promote [39, 40], which are often cited

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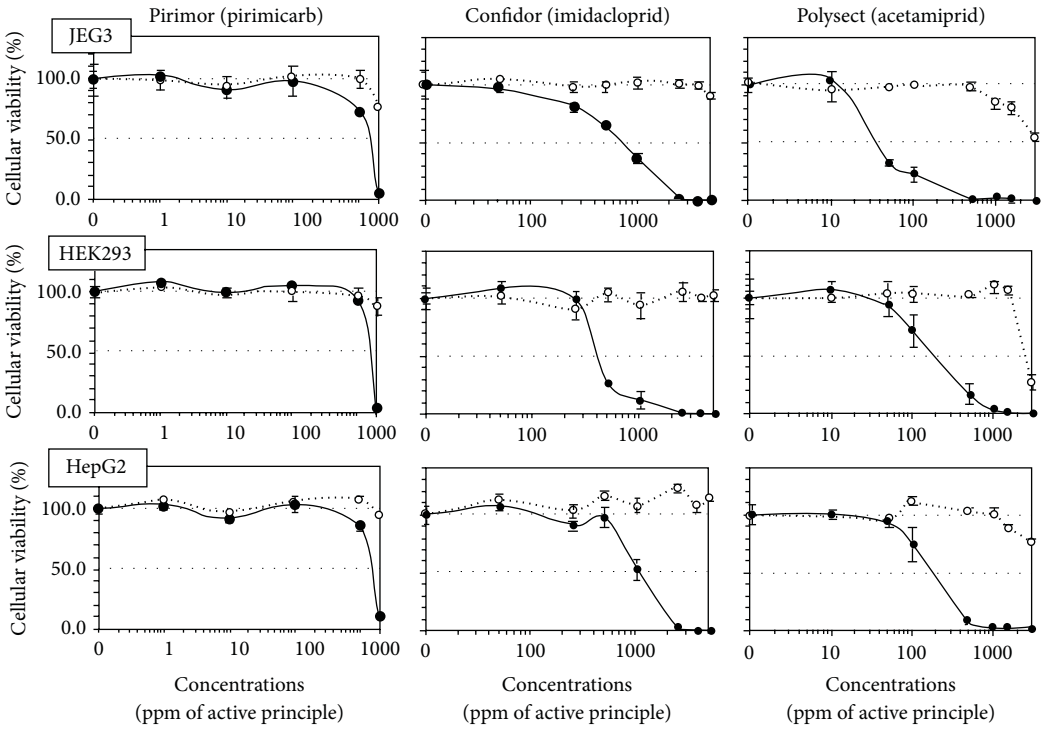

Figure 2: Differential cytotoxic effects between formulations of insecticides and their APs on HepG2, HEK293, and JEG3 human cell lines. The three described human cell lines were used in the conditions of Figure 1 and the results were almost identical. All formulations (solid line) are more toxic than their APs (dotted line); APs are slightly cytotoxic. SEMs are shown in all instances ($n = 9$).

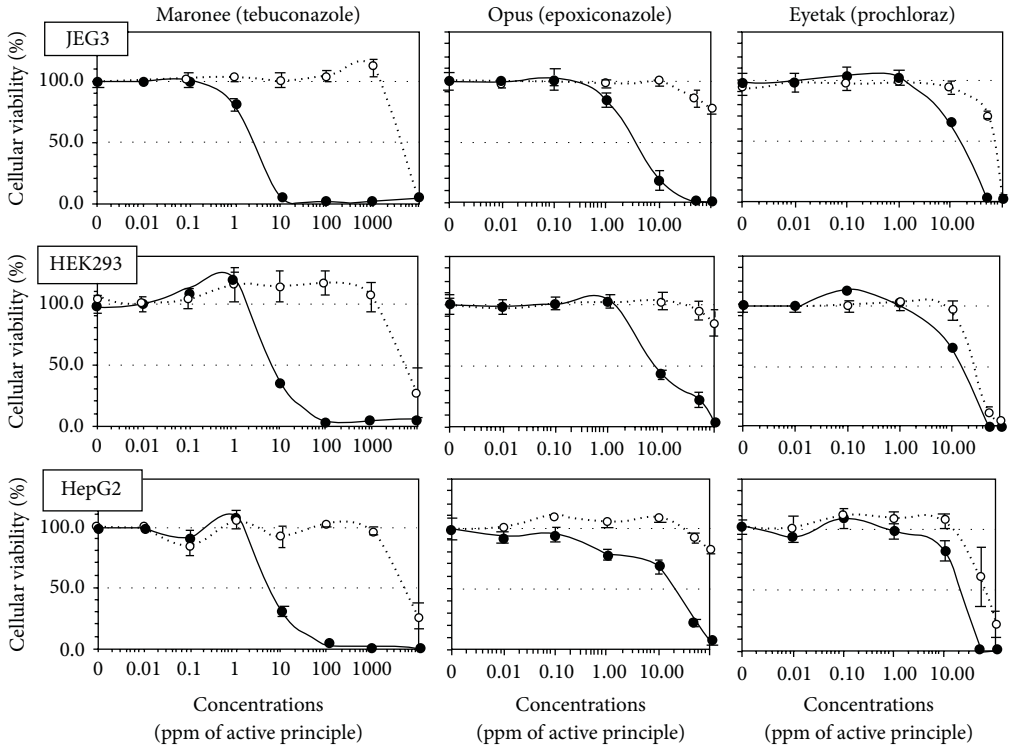

Figure 3: Differential cytotoxic effects between formulations of fungicides and their APs on HepG2, HEK293, and JEG3 human cell lines. The three described human cell lines were used in the culture conditions of Figure 1, and the results were almost identical. All formulations (solid line) are more cytotoxic than their APs (dotted line). Maronee is the most toxic compound tested from 1 ppm in JEG3. SEMs are shown in all instances ($n = 9$).

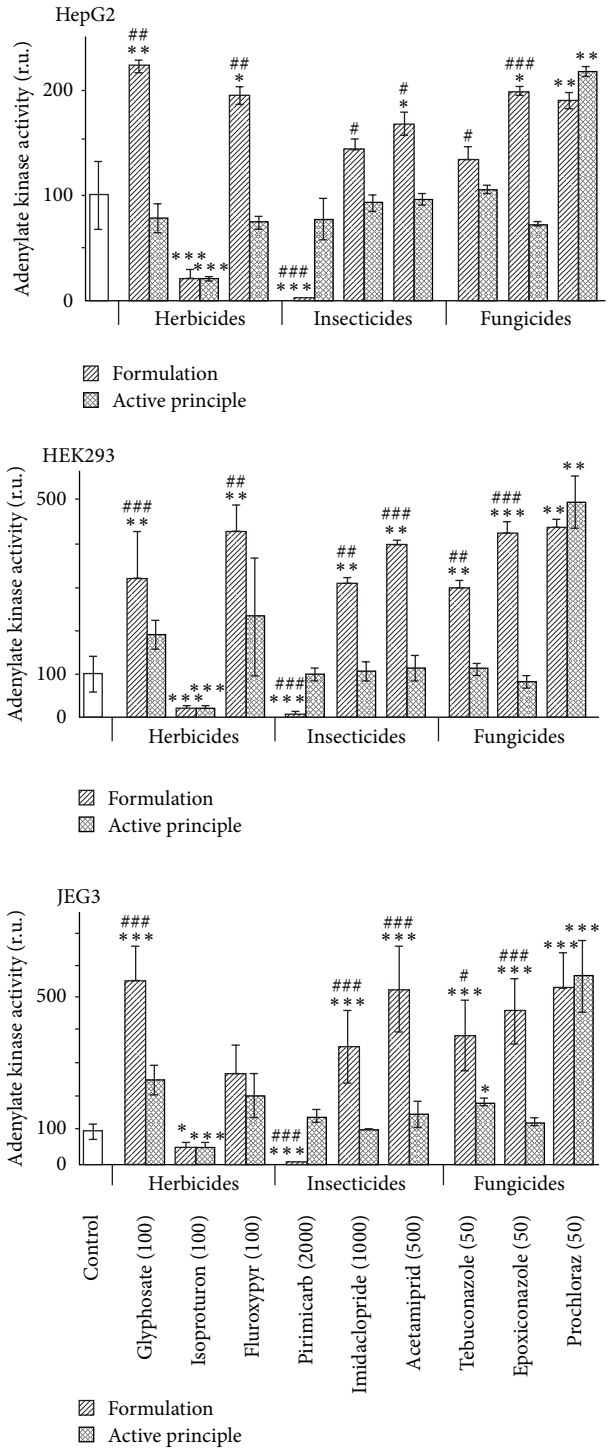

Figure 4: Differential necrotic effects between formulations and their APs. The three described human cell lines were used in the culture conditions of Figure 1. We have chosen the doses at the first differential effects measured by MTT assay. Formulations (stripped columns, expressed in ppm of the AP) are generally more cytotoxic than their APs (dashed columns) due to a necrotic effect of adjuvants. SEMs are shown in all instances ($n = 9$). For the comparison of each AP or formulation to the control (white column), $^{*}P < 0.05$, $^{**}P < 0.01$, and $^{***}P < 0.001$ in a nonparametric Mann-Whitney test. # symbol is used similarly for comparisons between APs and their formulations.

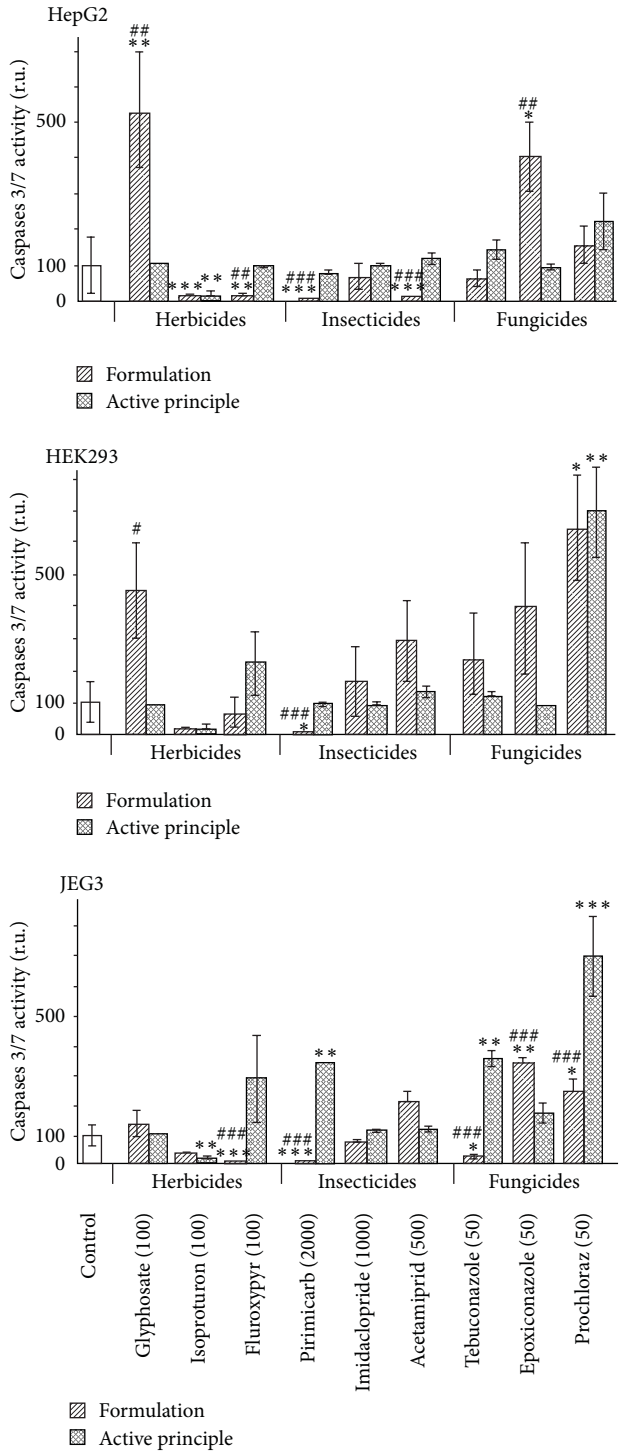

Figure 5: Differential apoptotic effects between formulations and their APs. The three described human cell lines were used in the culture conditions of Figure 1. We have chosen the doses at the first differential effects measured by MTT assay. SEMs are shown in all instances ($n = 9$). For the comparison of each AP or formulation to the control (white column), $^{*}P < 0.05$, $^{**}P < 0.01$, and $^{***}P < 0.001$ in a nonparametric Mann-Whitney test. # symbol is used similarly for comparisons between APs and their formulations.

in toxicological evaluations of glyphosate-based herbicides. However, Roundup was found in this experiment to be 125 times more toxic than glyphosate. Moreover, despite its reputation, Roundup was by far the most toxic among the herbicides and insecticides tested. This inconsistency between scientific fact and industrial claim may be attributed to huge economic interests, which have been found to falsify health risk assessments and delay health policy decisions [41].

In conclusion, our results challenge the relevance of the ADI, because it is calculated today from the toxicity of the AP alone in vivo. An "adjuvant factor" of at least a reduction by 100 can be applied to the present calculation of the ADI if this is confirmed by other studies in vivo. As an example, the present ADI for glyphosate is 0.3 ppm; for glyphosate-based herbicides it would be 3 ppb or less. However, this will never replace the direct study of the commercial formulation with its adjuvants in regulatory tests. Anyway, an exposure to a single formulated pesticide must be considered as coexposure to an active principle and the adjuvants. In addition, the study of combinatorial effects of several APs together may be very secondary if the toxicity of the combinations of each AP with its adjuvants is neglected or unknown. Even if all these factors were known and taken into account in the regulatory process, this would not exclude an endocrine-disrupting effect below the toxicity threshold. The chronic tests of pesticides may not reflect relevant environmental exposures if only one ingredient is tested alone.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

Acknowledgments

The authors acknowledge the Regional Council of Low Normandy for Robin Mesnage fellowship and the Charles Leopold Mayer (FPH) and Denis Guichard Foundations, together with CRIIGEN, for structural support. They are equally thankful to Malongo, Lea Nature, and the JMG Foundation for their help.

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Toxicology xxx (2012) xxx–xxx

Contents lists available at SciVerse ScienceDirect

Toxicology

journal homepage: www.elsevier.com/locate/toxicol

Ethoxylated adjuvants of glyphosate-based herbicides are active principles of human cell toxicity

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ARTICLE INFO

Article history:
Received 27 April 2012
Received in revised form 30 August 2012
Accepted 10 September 2012
Available online xxx

Keywords:
Pesticide
Glyphosate
POEA
Adjuvant
Roundup
Human cells

ABSTRACT

Pesticides are always used in formulations as mixtures of an active principle with adjuvants. Glyphosate, the active ingredient of the major pesticide in the world, is an herbicide supposed to be specific on plant metabolism. Its adjuvants are generally considered as inert diluents. Since side effects for all these compounds have been claimed, we studied potential active principles for toxicity on human cells for 9 glyphosate-based formulations. For this we detailed their compositions and toxicities, and as controls we used a major adjuvant (the polyethoxylated tallowamine POE-15), glyphosate alone, and a total formulation without glyphosate. This was performed after 24 h exposures on hepatic (HepG2), embryonic (HEK293) and placental (JEG3) cell lines. We measured mitochondrial activities, membrane degradations, and caspases 3/7 activities. The compositions in adjuvants were analyzed by mass spectrometry. Here we demonstrate that all formulations are more toxic than glyphosate, and we separated experimentally three groups of formulations differentially toxic according to their concentrations in ethoxylated adjuvants. Among them, POE-15 clearly appears to be the most toxic principle against human cells, even if others are not excluded. It begins to be active with negative dose-dependent effects on cellular respiration and membrane integrity between 1 and 3 ppm, at environmental/occupational doses. We demonstrate in addition that POE-15 induces necrosis when its first micellization process occurs, by contrast to glyphosate which is known to promote endocrine disrupting effects after entering cells. Altogether, these results challenge the establishment of guidance values such as the acceptable daily intake of glyphosate, when these are mostly based on a long term in vivo test of glyphosate alone. Since pesticides are always used with adjuvants that could change their toxicity, the necessity to assess their whole formulations as mixtures becomes obvious. This challenges the concept of active principle of pesticides for non-target species.

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1. Introduction

Pesticide formulations are mixtures of adjuvants and so-called "active principles" on plants for herbicides, and insects for insecticides, etc. The supposed specificity of active principles on their targets does not mean a priori that they are the most toxic compounds of the formulations on human cells. Numerous mammalian (Colborn et al., 1993) and other animal studies (Hawthorne and Dively, 2011) evidenced side effects for pesticides. The toxicology of mixtures cannot be fully understood without knowing the differential toxicity of the various compounds of the formulations and their combined effects. Surprisingly, to measure their side effects, the active principles of pesticides are generally tested alone at a regulatory level in long-term mammalian trials, although their adjuvants are developed at least to enhance their stability and penetration into cells. However, most of the adjuvants are classified as inert.

Here we tested the differential and combined cytotoxicity of the major pesticides in the world which are glyphosate-based herbicides (GBH), and analyzed their composition and mechanisms of action. The residues of the GBH such as Roundup (R) are also among the first contaminants of ground and surface waters (IFEN, 2006), and of some food and feed because they are present since more than 15 years in around two third of genetically modified (GM) cultivated edible plants, because they are designed at least to tolerate R (James, 2011). Glyphosate (G) is toxic in plant cells by inhibition of 5-enolpyruvylshikimate-3-phosphate synthase used as a first step in aromatic amino acid synthesis (Boocock and Coggins, 1983). Adjuvants considered as inert include, according to the formulations, surfactants like POEAs (polyethoxylated alkylamines,

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0300-483X/$ – see front matter © 2012 Published by Elsevier Ireland Ltd.
http://dx.doi.org/10.1016/j.tox.2012.09.006

https://d3n8a8pro7vhmx.cloudfront.net/yesmaam/pages/680/attachments/original/1407922431/
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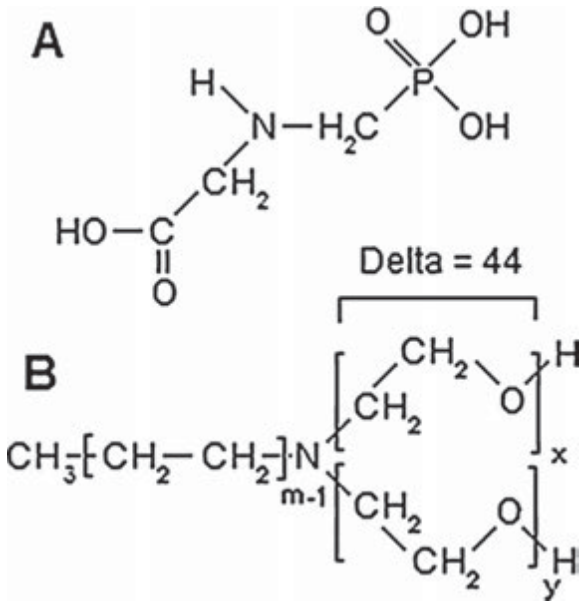

Fig. 1. Structures of glyphosate (A) and POEAs (B). Glyphosate is the N-(phosphonomethyl)glycine, C3H8NO5P). Di-ethoxylates of tallowamines adjuvants (C_mNEO_n, $n = x + y$) such as POEA are characterized by their oxide/tallowamine ratio. The delta of 44 (—CH_2—CH_2—O—) corresponded to the increment of the different peaks observed in mass spectrometry. Length of the more abundant tallowamine part in the adjuvant mixture corresponded to the maximal *m/z* of the spectrum.

Fig. 1), isobutane, light petroleum distillate, etc. that may induce among other DNA damages (Cox, 2004). However G is still generally hypothesized to be the active ingredient for non-target side effects. Unexpected side effects of G-based formulations were evidenced on non-target species, among other endocrine disruptions during spermatogenesis or pregnancy (Beuret et al., 2005; Clair et al., 2012; Dallegrave et al., 2007; Daruich et al., 2001; Oliveira et al., 2007; Romano et al., 2011; Savitz et al., 1997; Yousef et al., 1995). This may be related to adjuvants in formulation. They are indeed more and more considered as responsible for GBH toxicity (Mesnage et al., 2010; Williams et al., 2012), but the mechanistic and the nature of the cytotoxic agent(s) on human cells are still unknown. This is a general question that can arise for all pesticides.

The detailed known composition indicate that major adjuvants are ethoxylated, such as POEAs which are themselves mixtures of di-ethoxylates of tallowamines characterized by their oxide/tallowamine ratio. POEA commonly used in GBH is the POE (15) tallowamine (POE-15). We thus compared the toxicity and the composition of 9 formulations varying in adjuvants contents: Roundup Ultra, Roundup GT, Roundup GT+, Roundup Bioforce, Roundup 3plus, Glyphogan, Topglypho 360, Clinic E.V., and Bayer GC. For controls, we tested a formulation containing POE-15 without G (Genamin T200), and POE-15 alone. The compositional analysis of these products was performed by a non-quantitative mass spectrometry (MALDI-TOF MS/MS), considered as the best way to analyze pesticides formulations (Corbera et al., 2010; Cserháti and Forgács, 1997). Physico-chemical properties of POE-15 were approached by the measurements of its critical micelle concentration (CMC), determined by absorption changes in its presence of Coomassie blue CBB R-250.

We used HEK293, JEG3 and HepG2 cell lines, three models where unexpected effects of GBH have already been demonstrated (Benachour and Seralini, 2009; Gasnier et al., 2009). JEG3 cells are a useful model for examining placental toxicity (Letcher et al., 1999), and HepG2 for hepatic toxicity (Urani et al., 1998). HEK293 were chosen because of the sensitivity of embryonic cells, Roundup causing pregnancy outcomes (Savitz et al., 1997). Moreover, we have demonstrated that these cell lines are even less sensitive than primary cells (Benachour and Seralini, 2009; L'Azou et al., 2005), and therefore are possibly representative of a real cellular toxicity. For cytotoxicity measurements, we assayed mitochondrial succinate dehydrogenase (SD) activity (MTT assay), G and its formulations are indeed known to target mitochondria (Astiz et al., 2009; Peixoto, 2005). Cytotoxicity was also characterized by the measurement of apoptosis and necrosis, respectively by caspases 3/7 activation (Liu et al., 2005) and adenylate kinase leakage after membrane alterations (Crouch et al., 1993).

Overall, we questioned if an active toxic principle in a target species may be always generalized as such in a non target one, and thus if the regulatory toxicological tests on active principles alone are relevant.

2. Materials and methods

2.1. Chemicals

Glyphosate (N-phosphonomethyl glycine, G, CAS: 1071-83-6) was purchased from Sigma–Aldrich (Saint Quentin Fallavier, France). GBH formulations available on the market were by alphabetical order: Bayer GC (12.5% of G, 1–5% of POE-15, homologation 05873567), Clinic EV (42% of G, 11% of POE-15, homologation 9900039), Genamin T200 (60–80% of POE-15, homologation 8500170), Glyphogan (39–43% of G, 13–18% of POE-15, homologation 9100537), Roundup Grand Travaux (400 g/L of G, R GT, homologation 8800425), Roundup Grand Travaux plus (450 g/L of G, 90 g/L of ethoxylated etheralkylamine (EtO-EA), R GT+, homologation 2020448), Roundup Ultra (41.5% of G, 16% surfactant, homologation 9700259), Roundup Bioforce (360 g/L of G, homologation 9800036), Roundup 3plus (170 g/L of G, 8% surfactant homologation 9300241), Topglypho 360 (360 g/L of G, homologation 2000254). POE-15 (CAS: 61791-26-2) was purchased from ChemService (West Chester, PA, USA). 3-(4,5-Dimethylthiazol-2-yl)-2,5-diphenyl tetrazolium bromide (MTT) and all other compounds, otherwise noticed, were obtained from Sigma–Aldrich. MTT was prepared as a 5 mg/mL stock solution in phosphate-buffered saline, filtered through a 0.22 μm filter before use, and diluted to 1 mg/mL in a serum-free medium.

2.2. Cell lines and treatments

The human embryonic kidney 293 cell line (HEK 293, ECACC 85120602), was provided by Sigma–Aldrich (Saint-Quentin Fallavier, France). The hepatoma cell line HepG2 was provided by ECACC (85011430). JEG3 cell line (ECACC 92120308) was provided by CERDIC (Sophia-Antipolis, France). Cells were grown in phenol red-free EMEM (Abcys, Paris, France) containing 2 mM glutamine, 1% non-essential amino acid, 100 U/mL of antibiotics (a mixture of penicillin, streptomycin and fungizone) (Lonza, Saint Beauzire, France), 10 mg/mL of liquid kanamycin (Dominique Dutscher, Brumath, France) and 10% Fetal Bovine Serum (PAA, les Mureaux, France). JEG3 cells were supplemented with 1 mM sodium pyruvate. Cells were grown with this medium at 37 °C (5% CO_2, 95% air) during 48 h to 80% confluence, and then washed and exposed 24 h with serum-free EMEM to various chemicals. This model was validated (Benachour et al., 2007) since cytotoxic effects were similar in presence of serum but delayed by 48 h. The dilutions of formulated herbicides, adjuvants and G alone were prepared in serum free medium as stock solutions at a similar pH.

2.3. Cytotoxicity biomarkers

After treatments, the following tests were applied: succinate dehydrogenase (SD) activity assay (MTT) (Mosmann, 1983). Integrity of mitochondrial dehydrogenase enzymes indirectly reflects the cellular mitochondrial respiration. The optical density was measured at 570 nm using a Mithras LB 940 luminometer (Berthold, Thoiry, France). The bioluminescent ToxiLight bioassay (Lonza, Saint Beauzire, France) was applied for the membrane degradation assessment, by the intracellular adenylate kinase (AK) release in the medium; this is described as a necrosis marker (Crouch et al., 1993). Finally, the apoptotic cell death was evaluated with the Caspase-Glo 3/7 assay (Promega, Paris, France). Luminescence was measured using a Mithras LB 940 luminometer (Berthold, Thoiry, France). These methods were previously described (Benachour and Seralini, 2009).

2.4. Mass spectrometry (MS)

MS experiments were carried out on an AB Sciex 5800 proteomics analyzer equipped with TOF TOF ion optics and an OptiBeam™ on-axis laser irradiation with 1000 Hz repetition rate. The system was calibrated immediately before analysis with a mixture of des-Arg-Bradykinin, Angiotenin I, Glu1-Fibrinopeptide B, ACTH (18–39), ACTH (7–38) and mass precision was better than 50 ppm. A 0.8 μL volume of the GBH solution diluted 100 times in water was mixed with 1.6 μL volumes

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of solutions of α-cyano-4-hydroxycinnamic acid matrix prepared in 50% ACN with 0.1% TFA. The mixture was spotted on a stainless steel Opti-TOF™ 384 targets; the droplet was allowed to evaporate before introducing the target into the mass spectrometer. Acquisitions were taken in manual and automatic modes. A laser intensity of 3000 was typically employed for ionizing. MS spectra were acquired in the positive reflector mode by summarizing 1000 single spectra (5 × 200) in the mass range from 100 to 2000 Da. MS/MS spectra were acquired in the positive MS/MS reflector mode by summarizing a maximum of 2500 single spectra (10 × 250) with a laser intensity of 3900. For the tandem MS experiments, the acceleration voltage applied was 1 kV and air was used as the collision gas. Gas pressure medium was selected as settings.

2.5. Critical micelle concentrations (CMC) determinations

CMC determinations were performed and adapted according to (Samsonoff et al., 1986). CMC was measured by the incorporation of Coomassie brilliant blue R-250 (CBB-R250) in micelles formed by serial dilutions of detergents. The CCB-R250 reagent was prepared as previously described (Bradford, 1976). Varying concentrations of adjuvants were added in a volume of 1 mL, 100 μL of CBB-R250 was added to make a final concentration of 80 μg/mL. Solutions were shaken and distributed in 96 well-plates in triplicate. Absorption was then measured against a water blank at 600 nm using a Mithras LB 940 luminometer (Berthold, Thoiry, France). The validation of the technique was performed with triton X-100, with a CMC of 0.15–0.20 mM (Courtney et al., 1986).

2.6. Statistical analysis

The experiments were repeated at least 3 times in different weeks on 3 independent cultures ($n = 9$). LC_{50} values were calculated by a nonlinear regression using sigmoid (5-parameters) equation with the GraphPad software. All data were presented as the means ± standard errors (SEMs). Statistical differences were determined by Student's t-test using significant levels with $p < 0.01$ (**) and $p < 0.05$ (*).

3. Results

Here we studied for the first time the precise involvement of the adjuvants and G in GBH induced toxicity, on three human cell lines from different embryonic origins (kidney, liver, and placenta) in order to test their specificities. We first compared mitochondrial respiration (SD activity) in presence of 9 formulated mixtures of G and adjuvants, G alone, formulating agents without G (Genamin), and a major adjuvant of some formulations, POE-15 (Fig. 2). All chemicals are cytotoxic, inducing similar dose-dependent patterns on HEK293, HepG2, and JEG3 in 24 h. JEG3 were up to 2-fold more sensitive to treatments than HEK293 and HepG2 in comparison to control. We observed for all cell lines different ranges of toxicities

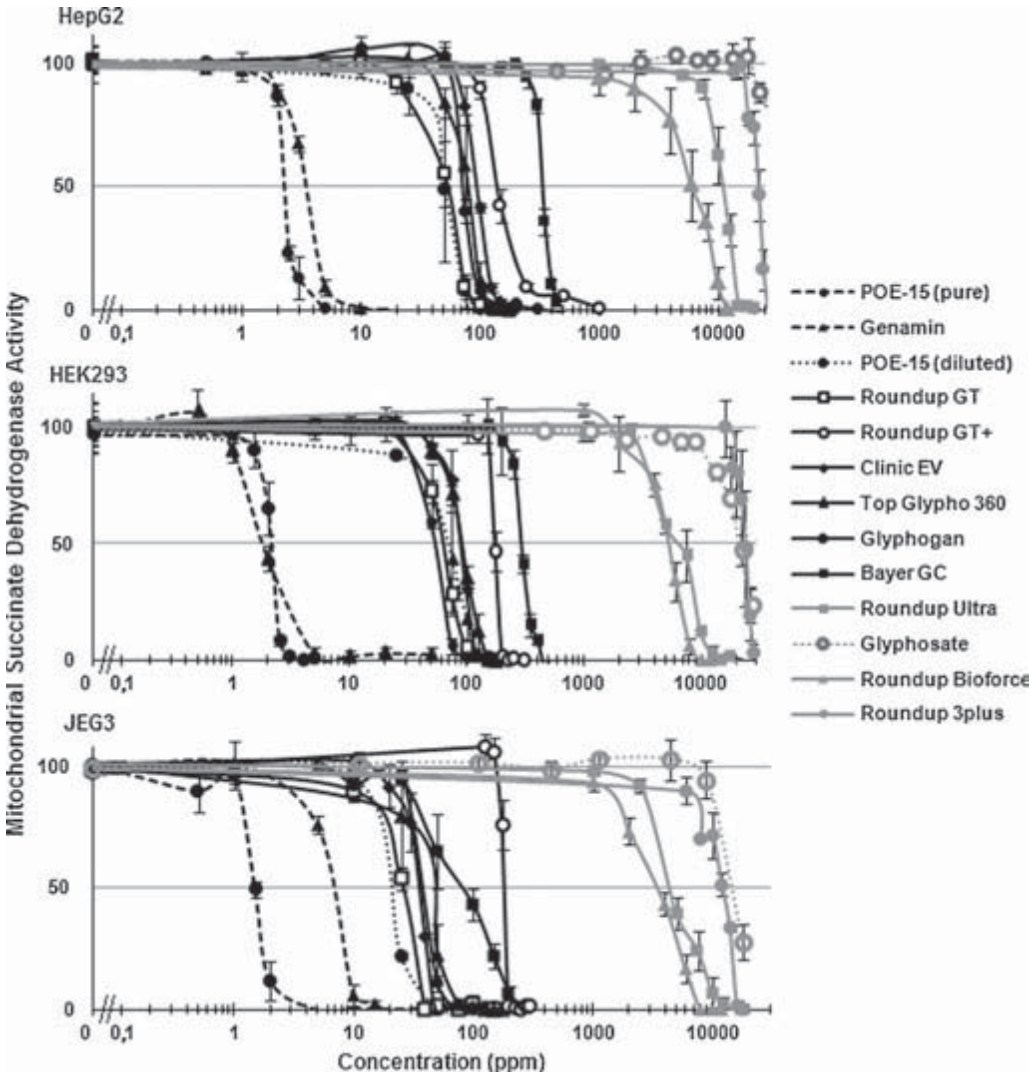

Fig. 2. Dose-dependent cytotoxic effects of glyphosate-based herbicides (GBH) or glyphosate (G) and adjuvants alone (POE-15 and Genamin) on HepG2, HEK293 and JEG3 human cell lines. Effects on the mitochondrial succinate dehydrogenase (SD) activity, reflecting cell respiration inhibition, were measured in % of control in serum-free medium after 24 h of exposure. The concentrations in ppm are dilutions of each mixture in the commercial formulation (considered as 100%). The adjuvants POE-15 and Genamin alone (a mixture containing 785 g/L of POE-15, no G) were the most toxic. The middle group approximately 100-fold less toxic was composed by GBH: Roundup GT, Roundup GT+, and Clinic EV, Top Glypho 360, Glyphogan, Bayer GC. The less toxic group was formed by Roundup Ultra, Bioforce and 3plus. SEMs are shown in all instances ($n = 9$).

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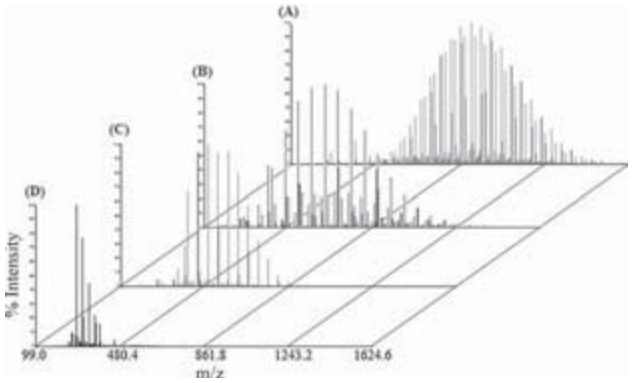

Fig. 3. MALDI-TOF analysis of glyphosate-based herbicides (GBH) main adjuvants. (A) POE-15 spectrum was centered on 900*m/z* (increment delta 44, Fig. 1), all other herbicides (group A, see Table 1) declaring a POEA adjuvant had the same spectrum. In addition, identification was confirmed by MS/MS fragmentation. (B) The 3 Roundup Ultra, Bioforce and 3plus contained another common adjuvant (600*m/z*, delta 58). (C) Adjuvants of Roundup GT+ (500*m/z*, delta 44, Fig. 1) were declared as ethoxylated etheralkylamines (EtO-EA). (D) Adjuvants of Roundup GT (300*m/z*, delta 44, Fig. 1) were identified as POE-2.

allowing the classification of the products tested as follows. The most toxic were the adjuvants alone POE-15 ($LC_{50} \sim 1$–2 ppm; agricultural dilutions: 1–2% of the herbicide formulation containing adjuvants) and Genamin, themselves around 100-fold more toxic than a middle group with the majority of formulations (6, with among them R GT and GT+). This middle group is again 100-fold more toxic than the third one which includes R Ultra, R Bioforce, R 3plus and finally G alone. Moreover, POE-15 diluted to the concentration at which it is present in Clinic E.V. (a formulation from the middle group) presented a similar toxicity than this GBH and to the middle group in general. It thus appears to be the toxic principle in human cells. In addition, we also demonstrate that two formulations claiming a similar concentration of G (360 g/L) and different adjuvants (16% of POEA or other adjuvants), Glyphogan and R Ultra respectively, exhibited very different toxicities, 150-fold stronger on average for Glyphogan on the 3 cell lines (Fig. 2). Thus some other adjuvants appear also to have some toxicity.

To check the composition in adjuvants we studied all the formulations by MALDI-TOF MS/MS (Fig. 3). Knowing that the specificities of MALDI-TOF ionization did not detect G but adjuvants, we separated 4 groups of adjuvants: (A) with a spectrum centered on 900*m/z*, POE-15 and Genamin, and those present in 4 formulations of the middle group thus containing also POE-15, (B) those contained in the third less toxic group with a spectrum centered on 600*m/z* corresponding to another common adjuvant, and (C) and (D), two other adjuvants in the formulations of the middle group, respectively in (C) R GT+ (500*m/z*) and (D) R GT (300*m/z*). The belonging of each product to each group was further confirmed by analysis of fragmentation spectra, giving for instance for ions of group A: 840.6, 858.7, 884.7, 902.8*m/z*. All these spectra corresponded to the family of alkylamines. The POE-15 had a peak increment of 44 (delta) like all group A (Table 1). The same delta in C and D were characteristic of an ethoxylated chain. C was an ethoxylated etheralkylamine, D was confirmed by fragmentation to be identical to POE-2; and a delta of 58 corresponded to another non ethoxylated adjuvant in group B. We summarized these findings with LC_{50} values (Table 1).

We then tested the linearity of the toxicity in function of G or ethoxylated adjuvants concentrations (Fig. 4). The cytotoxicity induced by GBH is not linear to G concentrations ($R^2 \sim 0.3$, Fig. 4A), but only to the 3 ethoxylated adjuvants ($R^2 > 0.93$, Fig. 4B), and not to the non-ethoxylated one, and this is obtained with all cell lines. Ethoxylated adjuvants can thus be considered as the active principle of the toxicity of GBH in human cells.

In order to understand the mechanism of action of adjuvants, three other experiments were performed. First, the critical micelle concentration (CMC) of POE-15 was determined by absorption changes of CBB R-250 (Fig. 5). The method was validated by the measurement of the CMC of the triton X-100 (0.15–0.20 mM (Courtney et al., 1986)). We evidenced a micellization of POE-15 beginning at 3 ppm, similarly to toxicity thresholds (Fig. 2). POE-15 thus appears to be able to disrupt the cellular membranes by micellization with the lipid bilayer around the CMC. This was even better understood by the differential measurement of the cytotoxicity through membrane disruption or caspases activation (Fig. 6). For the three cell lines, results are almost comparable: POE-15 and R GT+ (containing also an ethoxylated adjuvant) induced more necrosis (Fig. 6A) by membrane alterations rather than apoptosis (Fig. 6B), even if present. By contrast, G induced only apoptosis at higher levels. Ethoxylated adjuvants are thus not inert at all but cell membrane disruptors, and then induce severe mitochondrial alterations.

4. Discussion

This study unravels the differential nature and cytotoxicity of the main compounds from the major herbicide formulations in the world. These formulations are conceived to enhance the pesticide activity through mixtures of adjuvants and G. The latter is the active principle toxic in plants; in this study we checked how this

Table 1
Main spectral and toxicological characteristics of the herbicides (GBH) and adjuvants tested. Groups corresponded to spectra of adjuvants contained in products according to Fig. 3. Contents in glyphosate and adjuvants were indicated by manufacturers (except for POE-2) and identified by MS/MS as revealed by *m/z* and delta measurements. LC50 (ppm) are calculated from Fig. 2. nd: non detected; nk: not known.

Group	Products tested	Glyphosate (g/L)	Adjuvants	*m/z* (MS)	Delta (MS)	LC50 HepG2 (ppm)	LC50 HEK293 (ppm)	LC50 JEG3 (ppm)
A	Topglypho 360	360	15% POE-15	900	44	79	89	37
	Glyphogan	360	13–18% POE-15	900	44	59	54	30
	Clinic E.V	360	11% POE-15	900	44	94	89	34
	Bayer GC	96	1–5% POE-15	900	44	333	290	84
	Genamin	0	60–80% POE-15	900	44	4	2	7
	POE-15	0	POE-15	900	44	2	2	1
B	R Ultra	360	16% nk	600	58	11,000	6395	4477
	R Bioforce	360	nk	600	58	6106	5043	3560
	R 3plus	170	nk	600	58	22,000	24,000	1200
C	Roundup GT+	450	7.5% Eto-EA	500	44	145	170	115
D	Roundup GT	400	POE-2	300	44	53	62	32
	Glyphosate	>95%	nd	nd	nd	nd	19,323	1192

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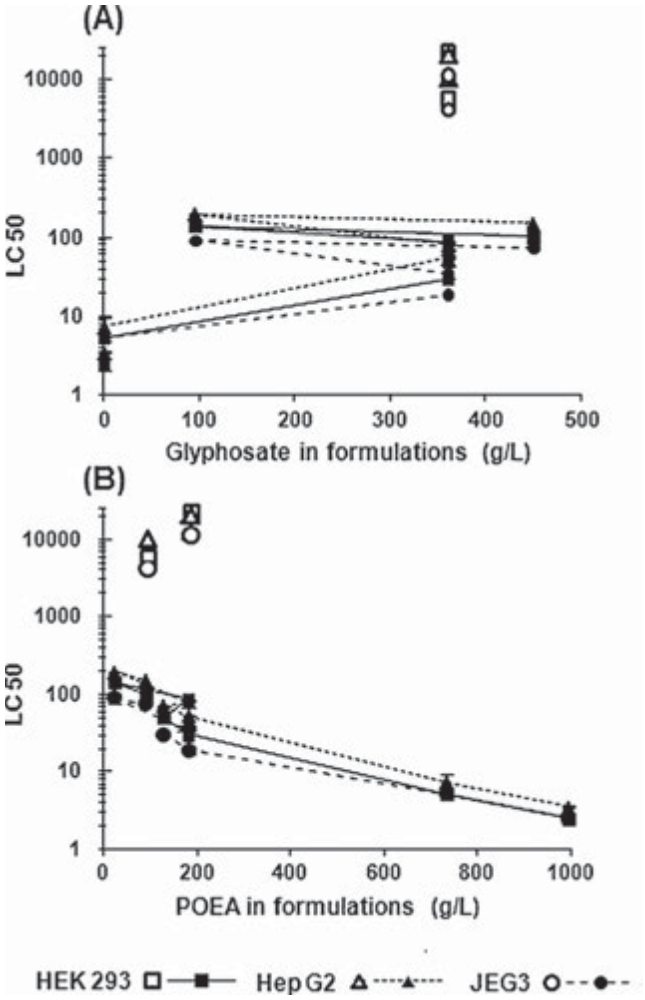

Fig. 4. Toxicity of glyphosate in formulations (A) measured by LC50, and of adjuvants in glyphosate-based herbicides (B) on the three human cell lines described. The effects on the mitochondrial succinate dehydrogenase (SD) activity were measured to calculate the LC50s (ppm) and compiled to be compared in relation to glyphosate or adjuvants concentrations. The form of the symbols is related to the cell lines (squares for HEK293, triangles for HepG2 and circles for JEG3). For colors, black dots are ethoxylated adjuvants, white dots are others. The three described human cell lines were used in the conditions of Fig. 2 and the results were almost identical. The linear correlation was not obtained (A) between glyphosate concentration and toxicity (coefficient of determination is 0.36 for HEK293, 0.35 for HepG2 and 0.29 for JEG3), but was demonstrated between the concentrations in the formulations of ethoxylated adjuvants (B) and toxicity (coefficient of determination is 0.94 for HEK293, 0.97 for HepG2 and 0.93 for JEG3). SEMs are represented in all instances ($n = 9$).

active principle is differentially toxic on non-target organisms in comparison to the so-called inert adjuvants in numerous formulations.

Here we demonstrate that all formulations are more toxic than G alone on three human cell lines as previously underlined (Benachour and Seralini, 2009; Richard et al., 2005). Then for the first time we separated experimentally three groups of formulations differentially toxic according to the amount of ethoxylated adjuvants. The 3 less toxic formulations (like G alone) were demonstrated to contain no ethoxylated adjuvants by mass spectrometry, and are around 10,000 times less toxic on mitochondrial activity than POE-15 alone, the major adjuvant. All the other formulations were toxic proportionally to the dilutions of POE-15 or other ethoxylated adjuvants in the formulations, in a linear manner to some extent; in fact G does not buffer or amplify direct POE-15 toxicity.

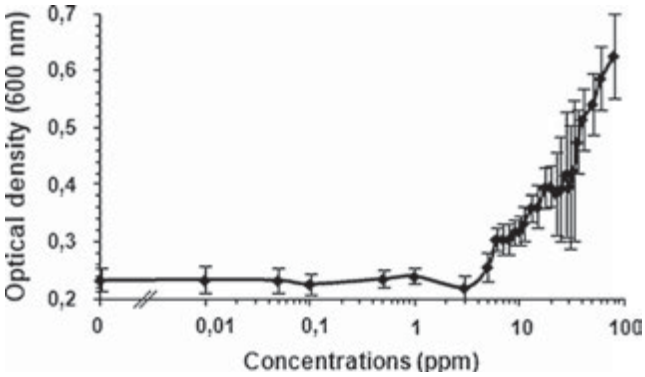

Fig. 5. Critical Micelle Concentration (CMC) of the POE-15 determined by absorption changes of Coomassie Brilliant Blue R-250. CBB R-250 was added to serial dilutions of POE-15 in serum-free medium. D.O. at 600 nm was measured with a spectrophotometer. A major breakpoint was evidenced in the curve around 3 ppm, at the CMC. SEMs are shown in all instances ($n = 9$).

Thus POE-15 appears to be clearly the toxic principle in human cells. It begins to be active with negative effects on cellular respiration and membrane integrity between 1 and 3 ppm, when its first micellization process occurs in this work. This membrane disruption then lead to the necrotic adjuvant-linked effects observed, amplifying the necrosis/apoptosis ratio by contrast to G at higher levels as shown. Accordingly, it was found (Chamel and Gambonnet, 1997) that a CMC of the $C_{18}NEO_{20}$ congener of a POEA is around 2 ppm. Its partition coefficient measured at around 1.7 confirmed its lipophilic character and its ability to penetrate the cells. It is known that ethoxylated adjuvants can insert in cells membranes, disrupting their structure and functions as previously shown in bacteria (Nobels et al., 2011). This is a general property of surfactants (Boeije et al., 2006). We notice that among different class of surfactants, ethoxylated adjuvants are of the more toxic, even potentially genotoxic (Nobels et al., 2011). Importantly, this is not only observed in vitro because when rats are treated with G, R and POEA, the latter was also found to be the most toxic compound (Adam et al., 1997), even in other animal models (Marc et al., 2005). This was demonstrated for other pesticides (Eddleston et al., 2012). Generally, the question of the toxicity of adjuvants in pesticides is more and more recognized (Brausch and Smith, 2007; Krogh et al., 2003; Tsui and Chu, 2003).

This does not exclude cellular endocrine disruptions below these levels that may not be due to POE-15 alone (or other ethoxylated adjuvants), but that occur through glyphosate entering in aromatase active site for instance (Richard et al., 2005) or in androgen receptor which is inhibited from 0.2 ppm of G in adjuvants (Gasnier et al., 2009). It should not be forgotten that G has its own toxicity and may also exert long term or chronic toxicity. The active principle G alone has been evidenced to cause oxidative stress (Astiz et al., 2009; Cavusoglu et al., 2011), endocrine disruption (Clair et al., 2012), or developmental effects (Marc et al., 2005). G was even recently described as a teratogen (Paganelli et al., 2010). In this case we have a model of multiple combined negative effects (through different cellular metabolic endpoints) caused by the main pesticide mixtures, which are the formulations themselves. This is true even if the activities of ethoxylated adjuvants on endocrine disruption must be still detailed in the future.

These results were obtained in vitro; cellular cultures replace whenever it is possible animal experimentation (Hartung, 2009). Our study was performed during 24 h and does not anticipate the elimination or the possible bioaccumulation and long term combined effects with other xenobiotics. R human cellular effects indeed increased according to time (Benachour et al., 2007) and radiolabeled G accumulated in cells within 48 h, suggesting a

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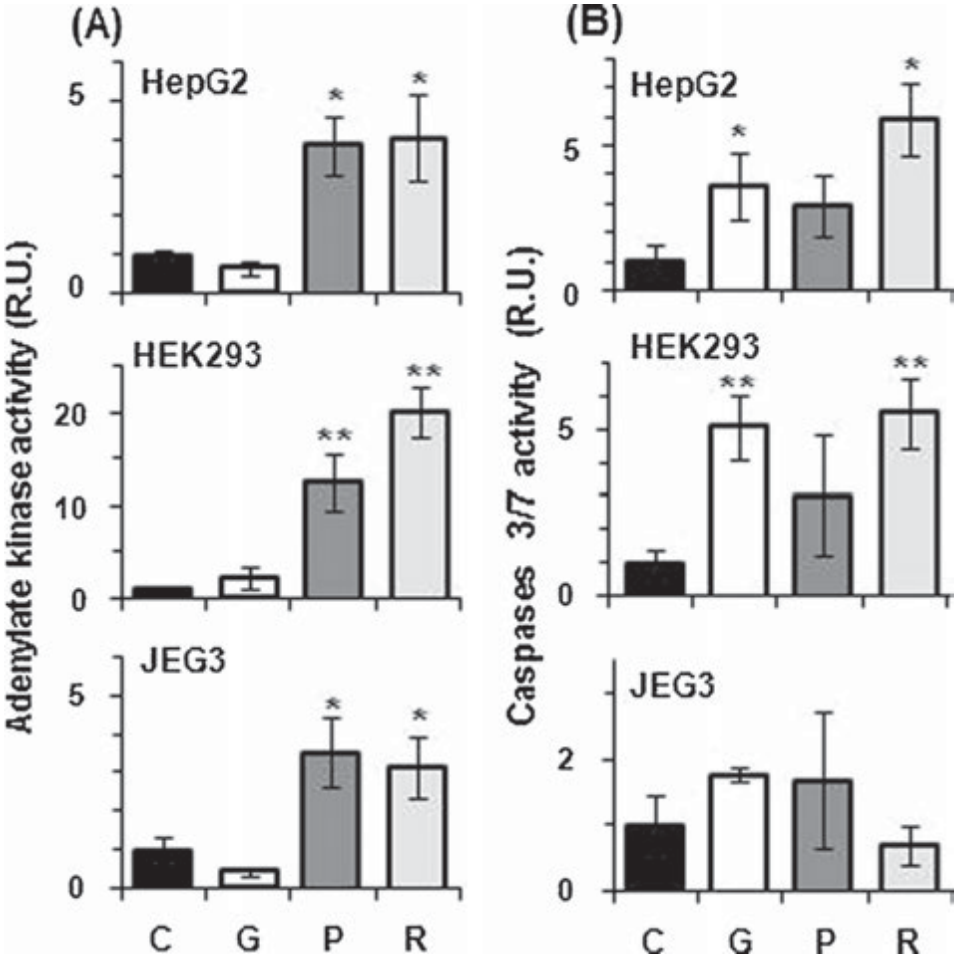

Fig. 6. Cytotoxic effects of control (C), glyphosate (G), POE-15 (P) and Roundup GT+ (R). Cell membrane integrity reflecting necrosis (A) was measured by adenylate kinase leakage (active in the medium), and apoptosis (B) by caspases 3/7 activities, both expressed in relative units (RU) after 24 h of treatments like in Fig. 2. To understand the mechanism of cytotoxicity, the concentrations in products were those inducing 80% of the general cytotoxicity in MTT assay. SEMs are shown in all instances ($n = 12$, $^{*}p < 0.05$; $^{**}p < 0.01$).

bioaccumulation of low concentrations of G (Gasnier et al., 2011). R adjuvants may also form adducts and link to DNA avoiding a direct elimination (Peluso et al., 1998).

However, our lowest thresholds of toxicities and endocrine disruptions may be comparable to the range of environmental/occupational exposures. A farmer or a gardener spraying a GBH may be punctually exposed to 5000 ppm, and even regularly by occupational exposure. As a matter of fact G varied from 3 to 233 ppb in farmers urine (Acquavella et al., 2004), this may be in addition to a chronic dietary/drink exposure of G found up to 70 ppb in serum of non-occupationally exposed women (Aris and Leblanc, 2011).

In conclusion, pesticide formulations should be studied as mixtures for toxic effects. The multiple combined effects could induce pathologies on a long term. Here we can question the use of ethoxylated adjuvants in herbicide formulations, since they appear as active principles for human cell toxicity. This leads also to challenge guidance values such as the acceptable daily intake (ADI) of G, which is calculated with pure G in long term toxicological tests in vivo (German Federal Agency CPFS, 1998), while G is always used with adjuvants that are not immediately biodegradable (Banduhn and Frazier, 1978) and could change its toxicity. This will be also important for other active principles of pesticides, and thus their ADI can be overestimated. The necessity of studying formulations as mixtures is common to all pesticides. The pathological consequences of exposure to chronic toxicities of whole formulations could be tested with mammals over a 2-year period. This implies a complete shift in the concepts underlying chemical toxicology, which could come from mixtures studies.

Conflict of interest

The authors declare that there are no conflicts of interest.

Acknowledgments

We gratefully thank Angelo San Filippo for technical support for adjuvants isolation. We acknowledge the Regional Council of Low Normandy for R.M. fellowship, but also the Charles Leopold Mayer (FPH) and Denis Guichard Foundations, together with CRIIGEN, for structural supports.

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GLYPHOSATE

1. Exposure Data

1.1 Identification of the agent

1.1.1 Nomenclature

Chem. Abstr. Serv. Reg. No.: 1071-83-6 (acid); also relevant:
38641-94-0 (glyphosate-isopropylamine salt)
40465-66-5 (monoammonium salt)
69254-40-6 (diammonium salt)
34494-03-6 (glyphosate-sodium)
81591-81-3 (glyphosate-trimesium)

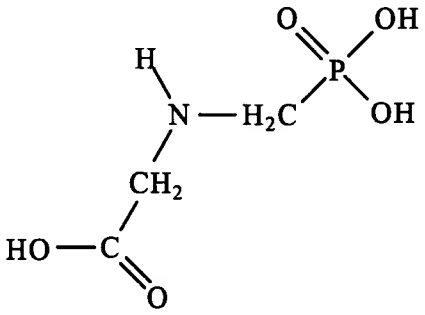
Chem. Abstr. Serv. Name: *N*-(phosphonomethyl)glycine

Preferred IUPAC Name: *N*-(phosphonomethyl)glycine

Synonyms: Gliphosate; glyphosate; glyphosate hydrochloride; glyphosate [calcium, copper (2+), dilithium, disodium, magnesium, monoammonium, monopotassium, monosodium, sodium, or zinc] salt

Trade names: Glyphosate products have been sold worldwide under numerous trade names, including: Abundit Extra; Credit; Xtreme; Glifonox; Glyphogan; Ground-Up; Rodeo; Roundup; Touchdown; Tragli; Wipe Out; Yerbimat (Farm Chemicals International, 2015).

1.1.2 Structural and molecular formulae and relative molecular mass



Molecular formula: $C_3H_8NO_5P$
Relative molecular mass: 169.07

Additional information on chemical structure is also available in the PubChem Compound database (NCBI, 2015).

1.1.3 Chemical and physical properties of the pure substance

Description: Glyphosate acid is a colourless, odourless, crystalline solid. It is formulated as a salt consisting of the deprotonated acid of glyphosate and a cation (isopropylamine, ammonium, or sodium), with more than one salt in some formulations.

Solubility: The acid is of medium solubility at 11.6 g/L in water (at 25 °C) and insoluble in common organic solvents such as acetone, ethanol, and xylene; the alkali-metal and

amine salts are readily soluble in water (Tomlin, 2000).

Volatility: Vapour pressure, 1.31×10^{-2} mPa at 25 °C (negligible) (Tomlin, 2000).

Stability: Glyphosate is stable to hydrolysis in the range of pH 3 to pH 9, and relatively stable to photodegradation (Tomlin, 2000). Glyphosate is not readily hydrolysed or oxidized in the field (Rueppel *et al.* 1977). It decomposes on heating, producing toxic fumes that include nitrogen oxides and phosphorus oxides (IPCS, 2005).

Reactivity: Attacks iron and galvanized steel (IPCS, 2005).

Octanol/water partition coefficient (P): log P, < –3.2 (pH 2–5, 20 °C) (OECD method 107) (Tomlin, 2000).

Henry's law: $< 2.1 \times 10^{-7}$ Pa m^3 mol^{-1} (Tomlin, 2000).

Conversion factor: Assuming normal temperature (25 °C) and pressure (101 kPa), mg/m^3 = 6.92 × ppm.

1.1.4 Technical products and impurities

Glyphosate is formulated as an isopropylamine, ammonium, or sodium salt in water-soluble concentrates and water-soluble granules. The relevant impurities in glyphosate technical concentrates are formaldehyde (maximum, 1.3 g/kg), *N*-nitrosoglyphosate (maximum, 1 mg/kg), and *N*-nitroso-*N*-phosphonomethylglycine (FAO, 2000). Surfactants and sulfuric and phosphoric acids may be added to formulations of glyphosate, with type and concentration differing by formulation (IPCS, 1994).

1.2 Production and use

1.2.1 Production

(a) Manufacturing processes

Glyphosate was first synthesized in 1950 as a potential pharmaceutical compound, but its herbicidal activity was not discovered until it was re-synthesized and tested in 1970 (Székács & Darvas, 2012). The isopropylamine, sodium, and ammonium salts were introduced in 1974, and the trimesium (trimethylsulfonium) salt was introduced in Spain in 1989. The original patent protection expired outside the USA in 1991, and within the USA in 2000. Thereafter, production expanded to other major agrochemical manufacturers in the USA, Europe, Australia, and elsewhere (including large-scale production in China), but the leading preparation producer remained in the USA (Székács & Darvas, 2012).

There are two dominant families of commercial production of glyphosate, the "alkyl ester" pathways, predominant in China, and the "iminodiacetic acid" pathways, with iminodiacetic acid produced from iminodiacetonitrile (produced from hydrogen cyanide), diethanol amine, or chloroacetic acid (Dill *et al.*, 2010; Tian *et al.*, 2012).

To increase the solubility of technical-grade glyphosate acid in water, it is formulated as its isopropylamine, monoammonium, potassium, sodium, or trimesium salts. Most common is the isopropylamine salt, which is formulated as a liquid concentrate (active ingredient, 5.0–62%), ready-to-use liquid (active ingredient, 0.5–20%), pressurized liquid (active ingredient, 0.75–0.96%), solid (active ingredient, 76–94%), or pellet/tablet (active ingredient, 60–83%) (EPA, 1993a).

There are reportedly more than 750 products containing glyphosate for sale in the USA alone (NPIC, 2010). Formulated products contain various non-ionic surfactants, most notably polyethyloxylated tallowamine (POEA), to

facilitate uptake by plants (Székács & Darvas, 2012). Formulations might contain other active ingredients, such as simasine, 2,4-dichlorophenoxyacetic acid (2,4-D), or 4-chloro-2-methylphenoxyacetic acid (IPCS, 1996), with herbicide resistance driving demand for new herbicide formulations containing multiple active ingredients (Freedonia, 2012).

(b) Production volume

Glyphosate is reported to be manufactured by at least 91 producers in 20 countries, including 53 in China, 9 in India, 5 in the USA, and others in Australia, Canada, Cyprus, Egypt, Germany, Guatemala, Hungary, Israel, Malaysia, Mexico, Singapore, Spain, Taiwan (China), Thailand, Turkey, the United Kingdom, and Venezuela (Farm Chemicals International, 2015). Glyphosate was registered in over 130 countries as of 2010 and is probably the most heavily used herbicide in the world, with an annual global production volume estimated at approximately 600 000 tonnes in 2008, rising to about 650 000 tonnes in 2011, and to 720 000 tonnes in 2012 (Dill *et al.*, 2010; CCM International, 2011; Hilton, 2012; Transparency Market Research, 2014).

Production and use of glyphosate have risen dramatically due to the expiry of patent protection (see above), with increased promotion of non-till agriculture, and with the introduction in 1996 of genetically modified glyphosate-tolerant crop varieties (Székács & Darvas, 2012). In the USA alone, more than 80 000 tonnes of glyphosate were used in 2007 (rising from less than 4000 tonnes in 1987) (EPA, 1997, 2011). This rapid growth rate was also observed in Asia, which accounted for 30% of world demand for glyphosate in 2012 (Transparency Market Research, 2014). In India, production increased from 308 tonnes in 2003–2004, to 2100 tonnes in 2007–2008 (Ministry of Chemicals & Fertilizers, 2008). China currently produces more than 40% of the global supply of glyphosate, exports almost 35% of the global supply (Hilton, 2012), and reportedly has sufficient production capacity to satisfy total global demand (Yin, 2011).

1.2.2 Uses

Glyphosate is a broad-spectrum, post-emergent, non-selective, systemic herbicide, which effectively kills or suppresses all plant types, including grasses, perennials, vines, shrubs, and trees. When applied at lower rates, glyphosate is a plant-growth regulator and desiccant. It has agricultural and non-agricultural uses throughout the world.

(a) Agriculture

Glyphosate is effective against more than 100 annual broadleaf weed and grass species, and more than 60 perennial weed species (Dill *et al.*, 2010). Application rates are about 1.5–2 kg/ha for pre-harvest, post-planting, and pre-emergence use; about 4.3 kg/ha as a directed spray in vines, orchards, pastures, forestry, and industrial weed control; and about 2 kg/ha as an aquatic herbicide (Tomlin, 2000). Common application methods include broadcast, aerial, spot, and directed spray applications (EPA, 1993a).

Due to its broad-spectrum activity, the use of glyphosate in agriculture was formerly limited to post-harvest treatments and weed control between established rows of tree, nut, and vine crops. Widespread adoption of no-till and conservation-till practices (which require chemical weed control while reducing soil erosion and labour and fuel costs) and the introduction of transgenic crop varieties engineered to be resistant to glyphosate have transformed glyphosate to a post-emergent, selective herbicide for use on annual crops (Duke & Powles, 2009; Dill *et al.* 2010). Glyphosate-resistant transgenic varieties have been widely adopted for the production of corn, cotton, canola, and soybean (Duke & Powles, 2009). Production of such crops accounted for 45% of worldwide demand for glyphosate in 2012 (Transparency Market Research, 2014). However, in Europe,

where the planting of genetically modified crops has been largely restricted, post-harvest treatment is still the most common application of glyphosate (Glyphosate Task Force, 2014). Intense and continuous use of glyphosate has led to the emergence of resistant weeds that may reduce its effectiveness (Duke & Powles, 2009).

(b) Residential use

Glyphosate is widely used for household weed control throughout the world. In the USA, glyphosate was consistently ranked as the second most commonly used pesticide (after 2,4-D) in the home and garden market sector between 2001 and 2007, with an annual use of 2000–4000 tonnes (EPA, 2011).

(c) Other uses

Glyphosate was initially used to control perennial weeds on ditch banks and roadsides and under power lines (Dill *et al.*, 2010). It is also used to control invasive species in aquatic or wetland systems (Tu *et al.*, 2001). Approximately 1–2% of total glyphosate use in the USA is in forest management (Mance, 2012).

Glyphosate has been used in a large-scale aerial herbicide-spraying programme begun in 2000 to reduce the production of cocaine in Colombia (Lubick, 2009), and of marijuana in Mexico and South America (Székács & Darvas, 2012).

(d) Regulation

Glyphosate has been registered for use in at least 130 countries (Dill *et al.*, 2010). In the USA, all uses are eligible for registration on the basis of a finding that glyphosate "does not pose unreasonable risks or adverse effects to humans or the environment" (EPA, 1993a). A review conducted in 2001 in connection with the registration process in the European Union reached similar conclusions regarding animal and human safety, although the protection of groundwater during non-crop use was identified as requiring particular attention in the short term (European Commission, 2002).

Nevertheless, as worldwide rates of adoption of herbicide-resistant crops and of glyphosate use have risen in recent years (Duke & Powles, 2009), restriction of glyphosate use has been enacted or proposed in several countries, although documented actions are few. In 2013, the Legislative Assembly of El Salvador voted a ban on the use of pesticides containing glyphosate (República de El Salvador, 2013). Sri Lanka is reported to have instituted a partial ban based on an increasing number of cases of chronic kidney disease among agricultural workers, but the ban was lifted after 2 months (ColomboPage, 2014). The reasons for such actions have included the development of resistance among weed species, as well as health concerns.

No limits for occupational exposure were identified by the Working Group.

1.3 Measurement and analysis

Several methods exist for the measurement of glyphosate and its major metabolite aminomethyl phosphonic acid (AMPA) in various media, including air, water, urine, and serum (Table 1.1). The methods largely involve derivatization with 9-fluorenylmethyl chloroformate (FMOC-Cl) to reach sufficient retention in chromatographic columns (Kuang *et al.*, 2011; Botero-Coy *et al.*, 2013). Chromatographic techniques that do not require derivatization and enzyme-linked immunosorbent assays (ELISA) are under development (Sanchís *et al.*, 2012).

Table 1.1 Methods for the analysis of glyphosate

Sample matrix	Assay procedure	Limit of detection	Reference
Water	HPLC/MS (with online solid-phase extraction)	0.08 µg/L	Lee *et al.* (2001)
	ELISA	0.05 µg/L	Abraxis (2005)
	LC-LC-FD	0.02 µg/L	Hidalgo *et al.* (2004)
	Post HPLC column derivatization and FD	6.0 µg/L	EPA (1992)
	UV visible spectrophotometer (at 435 ng)	1.1 µg/L	Jan *et al.* (2009)
Soil	LC–MS/MS with triple quadrupole	0.02 mg/kg	Botero-Coy *et al.* (2013)
Dust	GC-MS-MID	0.0007 mg/kg	Curwin *et al.* (2005)
Air	HPLC/MS with online solid-phase extraction	0.01 ng/m³	Chang *et al.* (2011)
Fruits and vegetables	HILIC/WAX with ESI-MS/MS	1.2 µg/kg	Chen *et al.* (2013)
Field crops (rice, maize and soybean)	LC–ESI-MS/MS	0.007–0.12 mg/kg	Botero-Coy *et al.* (2013b)
Plant vegetation	HPLC with single polymeric amino column	0.3 mg/kg	Nedelkoska & Low (2004)
Serum	LC–MS/MS	0.03 µg/mL 0.02 µg/mL (aminomethylphosphonic acid) 0.01 µg/mL (3-methylphosphinicopropionic acid)	Yoshioka *et al.* (2011)
Urine	HPLC with post-column reaction and FD	1 µg/L	Acquavella *et al.* (2004)
	ELISA	0.9 µg/L	Curwin *et al.* (2007)

ELISA, enzyme-linked immunosorbent assay; ESI-MS/MS, electrospray tandem mass spectrometry; FD, fluorescence detection; GC-MS-MID, gas chromatography-mass spectrometry in multiple ion detection mode; HILIC/WAX, hydrophilic interaction/weak anion-exchange liquid chromatography; HPLC/MS, high-performance liquid chromatography with mass spectrometry; HPLC, high-performance liquid chromatography; LC-ESI-MS/MS, liquid chromatography-electrospray–tandem mass spectrometry; LC–LC, coupled-column liquid chromatography; LC–MS/MS, liquid chromatography–tandem mass spectrometry

1.4 Occurrence and exposure

1.4.1 Exposure

(a) Occupational exposure

Studies related to occupational exposure to glyphosate have included farmers and tree nursery workers in the USA, forestry workers in Canada and Finland, and municipal weed-control workers in the United Kingdom (Centre de Toxicologie du Québec, 1988; Jauhiainen *et al.*, 1991; Lavy *et al.*, 1992; Acquavella *et al.*, 2004; Johnson *et al.*, 2005). Para-occupational exposures to glyphosate have also been measured in farming families (Acquavella *et al.*, 2004; Curwin *et al.*, 2007). These studies are summarized in Table 1.2.

(b) Community exposure

Glyphosate can be found in soil, air, surface water, and groundwater (EPA, 1993a). Once in the environment, glyphosate is adsorbed to soil and is broken down by soil microbes to AMPA (Borggaard & Gimsing, 2008). In surface water, glyphosate is not readily broken down by water or sunlight (EPA, 1993a). Despite extensive worldwide use, there are relatively few studies

Table 1.2 Occupational and para-occupational exposure to glyphosate

Industry, country, year	Job/process	Results	Comments/additional data	Reference
Forestry				
Canada, 1986		Arithmetic mean of air glyphosate concentrations:	Air concentrations of glyphosate were measured at the work sites of one crew (five workers) during ground spraying 268 urine samples were collected from 40 workers; glyphosate concentration was above the LOD (15 µg/L) in 14%	Centre de Toxicologie du Québec (1988)
	Signaller	Morning, 0.63 µg/m³ Afternoon, 2.25 µg/m³		
	Operator	Morning, 1.43 µg/m³ Afternoon, 6.49 µg/m³		
	Overseer	Morning, 0.84 µg/m³ Afternoon, 2.41 µg/m³		
	Mixer	Morning, 5.15 µg/m³ Afternoon, 5.48 µg/m³		
Finland, year NR	Workers performing silvicultural clearing (n = 5)	Range of air glyphosate concentrations, < 1.25–15.7 µg/m³ (mean, NR)	Clearing work was done with brush saws equipped with pressurized herbicide sprayers Air samples were taken from the workers' breathing zone (number of samples, NR) Urine samples were collected during the afternoons of the working week (number, NR) Glyphosate concentrations in urine were below the LOD (10 µg/L)	Jauhiainen *et al.* (1991)
USA, year NR	Workers in two tree nurseries (n = 14)	In dermal sampling, 1 of 78 dislodgeable residue samples were positive for glyphosate The body portions receiving the highest exposure were ankles and thighs	Dermal exposure was assessed with gauze patches attached to the clothing and hand rinsing Analysis of daily urine samples repeated over 12 weeks was negative for glyphosate	Lavy *et al.* (1992)
Weed control				
United Kingdom, year NR	Municipal weed control workers (n = 18)	Median, 16 mg/m³ in 85% of 21 personal air samples for workers spraying with mechanized all-terrain vehicle Median, 0.12 mg/m³ in 33% of 12 personal air samples collected from workers with backpack with lance applications	[The Working Group noted that the reported air concentrations were substantially higher than in other studies, but was unable to confirm whether the data were for glyphosate or total spray fluid] Dermal exposure was also measured, but reported as total spray fluid, rather than glyphosate	Johnson *et al.* (2005)

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Table 1.2 (continued)

Industry, country, year	Job/process	Results	Comments/additional data	Reference
Farming				
USA, 2001	Occupational and para-occupational exposure of 24 farm families (24 fathers, 24 mothers and 65 children). Comparison group: 25 non-farm families (23 fathers, 24 mothers and 51 children)	Geometric mean (range) of glyphosate concentrations in urine: Non-farm fathers, 1.4 µg/L (0.13–5.4) Farm fathers, 1.9 µg/L (0.02–18) Non-farm mothers, 1.2 µg/L (0.06–5.0) Farm mothers, 1.5 µg/L (0.10–11) Non-farm children, 2.7 µg/L (0.10–9.4) Farm children, 2.0 µg/L (0.02–18)	Frequency of glyphosate detection ranged from 66% to 88% of samples (observed concentrations below the LOD were not censored). Detection frequency and geometric mean concentration were not significantly different between farm and non-farm families (observed concentrations below the LOD were not censored)	Curwin *et al.* (2007)
USA, year NR	Occupational and para-occupational exposures of 48 farmers, their spouses, and 79 children	Geometric mean (range) of glyphosate concentration in urine on day of application: Farmers, 3.2 µg/L (< 1 to 233 µg/L) Spouses, NR (< 1 to 3 µg/L) Children, NR (< 1 to 29 µg/L)	24-hour composite urine samples for each family member the day before, the day of, and for 3 days after a glyphosate application. Glyphosate was detected in 60% of farmers' samples, 4% of spouses' samples and 12% of children's samples the day of spraying and in 27% of farmers' samples, 2% of spouses' samples and 5% of children's samples 3 days after	Acquavella *et al.* (2004)

LOD, limit of detection; ND, not detected; NR, not reported

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on the environmental occurrence of glyphosate (Kolpin *et al.*, 2006).

(i) Air

Very few studies of glyphosate in air were available to the Working Group. Air and rainwater samples were collected during two growing seasons in agricultural areas in Indiana, Mississippi, and Iowa, USA (Chang *et al.*, 2011). The frequency of glyphosate detection ranged from 60% to 100% in air and rain samples, and concentrations ranged from < 0.01 to 9.1 ng/m³ in air samples and from < 0.1 to 2.5 µg/L in rainwater samples. Atmospheric deposition was measured at three sites in Alberta, Canada. Rainfall and particulate matter were collected as total deposition at 7-day intervals throughout the growing season. Glyphosate deposition rates ranged from < 0.01 to 1.51 µg/m² per day (Humphries *et al.*, 2005).

No data were available to the Working Group regarding glyphosate concentrations in indoor air.

(ii) Water

Glyphosate in the soil can leach into groundwater, although the rate of leaching is believed to be low (Borggaard & Gimsing, 2008; Simonsen *et al.*, 2008). It can also reach surface waters by direct emission, atmospheric deposition, and by adsorption to soil particles suspended in runoff water (EPA, 1993a; Humphries *et al.*, 2005). Table 1.3 summarizes data on concentrations of glyphosate or AMPA in surface water and groundwater.

(iii) Residues in food and dietary intake

Glyphosate residues have been measured in cereals, fruits, and vegetables (Table 1.4). Residues were detected in 0.04% of 74 305 samples of fruits, vegetables, and cereals tested from 27 member states of the European Union, and from Norway, and Iceland in 2007 (EFSA, 2009). In cereals, residues were detected in 50% of samples tested in Denmark in 1998–1999, and in 9.5% of samples tested from member states of the European Union, and from Norway and Iceland in 2007 (Granby & Vahl, 2001; EFSA, 2009). In the United Kingdom, food sampling for glyphosate residues has concentrated mainly on cereals, including bread and flour. Glyphosate has been detected regularly and usually below the reporting limit (Pesticide Residues Committee, 2007, 2008, 2009, 2010). Six out of eight samples of tofu made from Brazilian soy contained glyphosate, with the highest level registered being 1.1 mg/kg (Pesticide Residues Committee, 2007).

(iv) Household exposure

In a survey of 246 California households, 14% were found to possess at least one product containing glyphosate (Guha *et al.*, 2013).

(v) Biological markers

Glyphosate concentrations in urine were analysed in urban populations in Europe, and in a rural population living near areas sprayed for drug eradication in Colombia (MLHB, 2013; Varona *et al.*, 2009). Glyphosate concentrations in Colombia were considerably higher than in Europe, with means of 7.6 ng/L and 0.02 µg/L, respectively (Table 1.5). In a study in Canada, glyphosate concentrations in serum ranged from undetectable to 93.6 ng/mL in non-pregnant women ($n = 39$), and were undetectable in serum of pregnant women ($n = 30$) and fetal cord serum (Aris & Leblanc, 2011).

1.4.2 Exposure assessment

Exposure assessment methods in epidemiological studies on glyphosate and cancer are discussed in Section 2.0 of the *Monograph* on Malathion, in the present volume.

Table 1.3 Concentration of glyphosate and AMPA in water

Country, year of sampling	Number of samples/setting	Results	Comments/additional data	Reference
USA, 2002	51 streams/agricultural areas (154 samples)	Maximum glyphosate concentration, 5.1 µg/L Maximum AMPA concentration, 3.67 µg/L	The samples were taken following pre- and post-emergence application and during harvest season Glyphosate detected in 36% of samples; AMPA detected in 69% of samples	Battaglin *et al.*, (2005)
USA, 2002	10 wastewater treatment plants and two reference streams (40 samples)	Glyphosate, range ≤ 0.1–2 µg/L AMPA, range ≤ 0.1–4 µg/L	AMPA was detected more frequently (67.5%) than glyphosate (17.5%)	Kolpin *et al.* (2006)
Canada, 2002	3 wetlands and 10 agricultural streams (74 samples)	Range, < 0.02–6.08 µg/L	Glyphosate was detected in most of the wetlands and streams (22% of samples)	Humphries *et al.* (2005)
Colombia, year NR	5 areas near crops and coca eradication (24 samples)	Maximum concentration, 30.1 µg/L (minimum and mean, NR)	Glyphosate detected in 8% of samples (MDL, 25 µg/L)	Solomon *et al.*, (2007)
Denmark, 2010–2012	4 agricultural sites (450 samples)	Range, < 0.1–31.0 µg/L	Glyphosate detected in 23% of samples; AMPA detected in 25% of samples	Brüch *et al.* (2013)

AMPA, aminomethylphosphonic acid; MDL, method detection limit; NR, data not reported

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Table 1.4 Concentrations of glyphosate in food

Country, year	Type of food	Results	Comments/additional data	Reference
Denmark, 1998, 1999	Cereals	> 50% of samples had detectable residues Means: 0.08 mg/kg in 1999 and 0.11 mg/kg in 1998	49 samples of the 1998 harvest 46 samples of the 1999 harvest	Granby & Vahl (2001)
27 European Union member states, Norway and Iceland, 2007	350 different food commodities	0.04% of 2302 fruit, vegetable and cereal samples 9.5% of 409 cereal samples	74 305 total samples	EFSA (2009)
Australia, 2006	Composite sample of foods consumed in 24 hours	75% of samples had detectable residues Mean, 0.08 mg/kg Range, < 0.005 to 0.5 mg/kg	20 total samples from 43 pregnant women	McQueen *et al.* (2012)

Table 1.5 Concentrations of glyphosate and AMPA in urine and serum in the general population

Country, period	Subjects	Results	Comments/additional data	Reference
Urine				
18 European countries, 2013	162 individuals	Arithmetic mean of glyphosate concentration: 0.21 µg/L (maximum, 1.56 µg/L) Arithmetic mean of AMPA concentration: 0.19 µg/L (maximum, 2.63 µg/L)	44% of samples had quantifiable levels of glyphosate and 36% had quantifiable levels of AMPA	MLHB (2013)
Colombia, 2005–2006	112 residents of areas sprayed for drug eradication	Arithmetic mean (range) of glyphosate concentration: 7.6 µg/L (ND–130 µg/L) Arithmetic mean (range) of AMPA concentration: 1.6 µg/L (ND–56 µg/L)	40% of samples had detectable levels of glyphosate and 4% had detectable levels of AMPA (LODs, 0.5 and 1.0 µg/L, respectively) Urinary glyphosate was associated with use in agriculture	Varona *et al.* (2009)
Serum				
Canada, NR	30 pregnant women and 39 non-pregnant women	ND in serum of pregnant women or cord serum; Arithmetic mean, 73.6 µg/L, (range, ND–93.6 µg/L) in non-pregnant women	No subject had worked or lived with a spouse working in contact with pesticides LOD, 15 µg/L	Aris & Leblanc (2011)

AMPA, aminomethylphosphonic acid; LOD, limit of detection; ND, not detected; NR, not reported

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2. Cancer in Humans

2.0 General discussion of epidemiological studies

A general discussion of the epidemiological studies on agents considered in Volume 112 of the *IARC Monographs* is presented in Section 2.0 of the *Monograph* on Malathion.

2.1 Cohort studies

See Table 2.1

The Agricultural Health Study (AHS), a large prospective cohort study conducted in Iowa and North Carolina in the USA, is the only cohort study to date to have published findings on exposure to glyphosate and the risk of cancer at many different sites (Alavanja *et al.*, 1996; NIH, 2015) (see Section 2.0 of the *Monograph* on Malathion, in the present volume, for a detailed description of this study).

The enrolment questionnaire from the AHS sought information on the use of 50 pesticides (ever or never exposure), crops grown and livestock raised, personal protective equipment used, pesticide application methods used, other agricultural activities and exposures, nonfarm occupational exposures, and several lifestyle, medical, and dietary variables. The duration (years) and frequency (days per year) of use was investigated for 22 of the 50 pesticides in the enrolment questionnaire. [Blair *et al.* (2011) assessed the possible impact of misclassification of occupational pesticide exposure on relative risks, demonstrating that nondifferential exposure misclassification biases relative risk estimates towards the null in the AHS and tends to decrease the study power.]

The first report of cancer incidence associated with pesticide use in the AHS cohort considered cancer of the prostate (Alavanja *et al.*, 2003). Risk estimates for exposure to glyphosate were not presented, but no significant exposure–response association with cancer of the prostate was found. In an updated analysis of the AHS (1993 to 2001), De Roos *et al.* (2005a) (see below) also found no association between exposure to glyphosate and cancer of the prostate (relative risk, RR, 1.1; 95% CI, 0.9–1.3) and no exposure–response trend (*P* value for trend = 0.69).

De Roos *et al.* (2005a) also evaluated associations between exposure to glyphosate and the incidence of cancer at several other sites. The prevalence of ever-use of glyphosate was 75.5% (> 97% of users were men). In this analysis, exposure to glyphosate was defined as: (a) ever personally mixed or applied products containing glyphosate; (b) cumulative lifetime days of use, or "cumulative exposure days" (years of use × days/year); and (c) intensity-weighted cumulative exposure days (years of use × days/year × estimated intensity level). Poisson regression was used to estimate exposure–response relations between exposure to glyphosate and incidence of all cancers combined, and incidence of 12 cancer types: lung, melanoma, multiple myeloma, and non-Hodgkin lymphoma (see Table 2.1) as well as oral cavity, colon, rectum, pancreas, kidney, bladder, prostate, and leukaemia (results not tabulated). Exposure to glyphosate was not associated with all cancers combined (RR, 1.0; 95% CI, 0.9–1.2; 2088 cases). For multiple myeloma, the relative risk was 1.1 (95% CI, 0.5–2.4; 32 cases) when adjusted for age, but was 2.6 (95% CI, 0.7–9.4) when adjusted for multiple confounders (age, smoking, other pesticides, alcohol consumption, family history of cancer, and education); in analyses by cumulative exposure-days and intensity-weighted exposure-days, the relative risks were around 2.0 in the highest tertiles. Furthermore, the association between multiple myeloma and exposure to glyphosate only appeared within the subgroup for which complete data were available on all the covariates; even without any adjustment, the risk of multiple myeloma associated with glyphosate use was increased by twofold among the smaller subgroup with available covariate data

Table 2.1 Cohort studies of cancer and exposure to glyphosate

Reference, study location, enrolment period/follow-up, study-design	Population size, description, exposure assessment method	Organ site (ICD code)	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled	Comments
De Roos *et al.* (2005a) Iowa and North Carolina, USA 1993–2001	54 315 (after exclusions, from a total cohort of 57 311) licensed pesticide applicators Exposure assessment method: questionnaire; semi-quantitative assessment from self-administered questionnaire	Lung	Ever use	147	0.9 (0.6–1.3)	Age, smoking, other pesticides, alcohol consumption, family history of cancer, education	AHS Cancer sites investigated: lung, melanoma, multiple myeloma and NHL (results tabulated) as well as oral cavity, colon, rectum, pancreas, kidney, bladder, prostate and leukaemia (results not tabulated) [Strengths: large cohort; specific assessment of glyphosate; semiquantitative exposure assessment. Limitations: risk estimates based on self-reported exposure; limited to licensed applicators; potential exposure to multiple pesticides]
			Cumulative exposure days:				
			1–20	40	1 (ref.)		
			21–56	26	0.9 (0.5–1.5)		
			57–2678	26	0.7 (0.4–1.2)		
			Trend-test *P* value: 0.21				
		Melanoma	Ever use	75	1.6 (0.8–3)		
			1–20	23	1 (ref.)		
			21–56	20	1.2 (0.7–2.3)		
			57–2678	14	0.9 (0.5–1.8)		
			Trend-test *P* value: 0.77				
		Multiple myeloma	Ever use	32	1.1 (0.5–2.4)	Age only (results in this row only)	
			Ever use	32	2.6 (0.7–9.4)		
			1–20	8	1 (ref.)		
			21–56	5	1.1 (0.4–3.5)		
			Trend-test *P* value: 0.27				
		NHL	Ever use	92	1.1 (0.7–1.9)		
			1–20	29	1 (ref.)		
			21–56	15	0.7 (0.4–1.4)		
			57–2678	17	0.9 (0.5–1.6)		
			Trend-test *P* value: 0.73				

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Table 2.1 (continued)

Reference, study location, enrolment period/follow-up, study-design	Population size, description, exposure assessment method	Organ site (ICD code)	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled	Comments
Flower *et al.* (2004) Iowa and North Carolina, USA Enrolment, 1993–1997; follow-up, 1975–1998	21 375; children (aged < 19 years) of licensed pesticide applicators in Iowa (n = 17 357) and North Carolina (n = 4018) Exposure assessment method: questionnaire	Childhood cancer	Maternal use of glyphosate (ever) Paternal use of glyphosate (prenatal)	13 6	0.61 (0.32–1.16) 0.84 (0.35–2.34)	Child's age at enrolment	AHS Glyphosate results relate to the Iowa participants only [Strengths: Large cohort; specific assessment of glyphosate. Limitations: based on self-reported exposure; potential exposure to multiple pesticides; limited power for glyphosate exposure]
Engel *et al.* (2005) Iowa and North Carolina, USA Enrolment, 1993–1997 follow-up to 2000	30 454 wives of licensed pesticide applicators with no history of breast cancer at enrolment Exposure assessment method: questionnaire	Breast	Direct exposure to glyphosate Husband's use of glyphosate	82 109	0.9 (0.7–1.1) 1.3 (0.8–1.9)	Age, race, state	AHS [Strengths: large cohort; specific assessment of glyphosate. Limitations: based on self-reported exposure; limited to licensed applicators; potential exposure to multiple pesticides]
Lee *et al.* (2007) Iowa and North Carolina, USA Enrolment, 1993–1997; follow-up to 2002	56 813 licensed pesticide applicators Exposure assessment method: questionnaire	Colorectum Colon Rectum	Exposed to glyphosate Exposed to glyphosate Exposed to glyphosate	225 151 74	1.2 (0.9–1.6)	Age, smoking, state, total days of any pesticide application	AHS [Strengths: large cohort. Limitations: based on self-reported exposure, limited to licensed applicators, potential

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Table 2.1 (continued)

Reference, study location, enrolment period/follow-up, study-design	Population size, description, exposure assessment method	Organ site (ICD code)	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled	Comments
Andreotti *et al.* (2009) Iowa and North Carolina, USA Enrolment, 1993–1997; follow-up to 2004 Nested case–control study	Cases: 93 (response rate, NR); identified from population-based state-cancer registries. Incident cases diagnosed between enrolment and 31 December 2004 (> 9 years follow-up) included in the analysis. Participants with any type of prevalent cancer at enrolment were excluded. Vital status was obtained from the state death registries and the National Death Index. Participants who left North Carolina or Iowa were not subsequently followed for cancer occurrence. Controls: 82 503 (response rate, NR); cancer-free participants enrolled in the cohort Exposure assessment method: questionnaire providing detailed pesticide use, demographic and lifestyle information. Ever-use of 24 pesticides and intensity-weighted lifetime days [(lifetime exposure days) × (exposure intensity score)] of 13 pesticides was assessed	Pancreas (C25.0–C25.9)	Ever exposure to glyphosate Low (< 185 days) High (≥ 185 days) Trend-test *P* value: 0.85	55 29 19	1.1 (0.6–1.7)	Age, smoking, diabetes	AHS [Strengths: large cohort. Limitations: based on self-reported exposure; limited to licensed applicators; potential exposure to multiple pesticides]

AHS, Agricultural Health Study; NHL, non-Hodgkin lymphoma; NR, not reported

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(De Roos *et al.*, 2005b). [The study had limited power for the analysis of multiple myeloma; there were missing data on covariates when multiple adjustments were done, limiting the interpretation of the findings.] A re-analysis of these data conducted by Sorahan (2015) confirmed that the excess risk of multiple myeloma was present only in the subset with no missing information (of 22 cases in the restricted data set). In a subsequent cross-sectional analysis of 678 male participants from the same cohort, Landgren *et al.* (2009) did not find an association between exposure to glyphosate and risk of monoclonal gammopathy of undetermined significance (MGUS), a premalignant plasma disorder that often precedes multiple myeloma (odds ratio, OR, 0.5; 95% CI, 0.2–1.0; 27 exposed cases).

Flower *et al.* (2004) reported the results of the analyses of risk of childhood cancer associated with pesticide application by parents in the AHS. The analyses for glyphosate were conducted among 17 357 children of Iowa pesticide applicators from the AHS. Parents provided data via questionnaires (1993–1997) and the cancer follow-up (retrospectively and prospectively) was done through the state cancer registries. Fifty incident childhood cancers were identified (1975–1998; age, 0–19 years). For all the children of the pesticide applicators, risk was increased for all childhood cancers combined, for all lymphomas combined, and for Hodgkin lymphoma, compared with the general population. The odds ratio for use of glyphosate and risk of childhood cancer was 0.61 (95% CI, 0.32–1.16; 13 exposed cases) for maternal use and 0.84 (95% CI, 0.35–2.34; 6 exposed cases) for paternal use. [The Working Group noted that this analysis had limited power to study a rare disease such as childhood cancer.]

Engel *et al.* (2005) reported on incidence of cancer of the breast among farmers' wives in the AHS cohort, which included 30 454 women with no history of cancer of the breast before enrolment in 1993–1997. Information on pesticide use and other factors was obtained at enrolment by self-administered questionnaire from the women and their husbands. A total of 309 incident cases of cancer of the breast were identified until 2000. There was no difference in incidence of cancer of the breast for women who reported ever applying pesticides compared with the general population. The relative risk for cancer of the breast among women who had personally used glyphosate was 0.9 (95% CI, 0.7–1.1; 82 cases) and 1.3 (95% CI, 0.8–1.9; 109 cases) among women who never used pesticides but whose husband had used glyphosate. [No information on duration of glyphosate use by the husband was presented.] Results for glyphosate were not further stratified by menopausal status.

Lee *et al.* (2007) investigated the relationship between exposure to agricultural pesticides and incidence of cancer of the colorectum in the AHS. A total of 56 813 pesticide applicators with no prior history of cancer of the colorectum were included in this analysis, and 305 incident cancers of the colorectum (colon, 212; rectum, 93) were diagnosed during the study period, 1993–2002. Most of the 50 pesticides studied were not associated with risk of cancer of the colorectum, and the relative risks with exposure to glyphosate were 1.2 (95% CI, 0.9–1.6), 1.0 (95% CI, 0.7–1.5), and 1.6 (95% CI, 0.9–2.9) for cancers of the colorectum, colon, and rectum, respectively.

Andreotti *et al.* (2009) examined associations between the use of pesticides and cancer of the pancreas using a case–control analysis nested in the AHS. This analysis included 93 incident cases of cancer of the pancreas (64 applicators, 29 spouses) and 82 503 cancer-free controls who completed the enrolment questionnaire. Ever-use of 24 pesticides and intensity-weighted lifetime days [(lifetime exposure days) × (exposure intensity score)] of 13 pesticides were assessed. Risk estimates were calculated controlling for age, smoking, and diabetes. The odds ratio for ever- versus never-exposure to glyphosate was

1.1 (95% CI, 0.6–1.7; 55 exposed cases), while the odds ratio for the highest category of level of intensity-weighted lifetime days was 1.2 (95% CI, 0.6–2.6; 19 exposed cases).

Dennis *et al.* (2010) reported that exposure to glyphosate was not associated with cutaneous melanoma within the AHS. [The authors did not report a risk estimate.]

2.2 Case–control studies on non-Hodgkin lymphoma, multiple myeloma, and leukaemia

2.2.1 Non-Hodgkin lymphoma

See Table 2.2

(a) Case–control studies in the midwest USA

Cantor *et al.* (1992) conducted a case–control study of incident non-Hodgkin lymphoma (NHL) among males in Iowa and Minnesota, USA (see the *Monograph* on Malathion, Section 2.0, for a detailed description of this study). A total of 622 white men and 1245 population-based controls were interviewed in person. The association with farming occupation and specific agricultural exposures were evaluated. When compared with non-farmers, the odds ratios for NHL were 1.2 (95% CI, 1.0–1.5) for men who had ever farmed, and 1.1 (95% CI, 0.7–1.9; 26 exposed cases; adjusted for vital status, age, state, cigarette smoking status, family history of lymphohaematopoietic cancer, high-risk occupations, and high-risk exposures) for ever handling glyphosate. [There was low power to assess the risk of NHL associated with exposure to glyphosate. There was no adjustment for other pesticides. These data were included in the pooled analysis by De Roos *et al.* (2003).]

Brown *et al.* (1993) reported the results of a study to evaluate the association between multiple myeloma and agricultural risk factors in the midwest USA (see the *Monograph* on Malathion, Section 2.0, for a detailed description of this study). A population-based case–control study of 173 white men with multiple myeloma and 650 controls was conducted in Iowa, USA, an area with a large farming population. A non-significantly elevated risk of multiple myeloma was seen among farmers compared with never-farmers. The odds ratio related to exposure to glyphosate was 1.7 (95% CI, 0.8–3.6; 11 exposed cases). [This study had limited power to assess the association between multiple myeloma and exposure to glyphosate. Multiple myeloma is now considered to be a subtype of NHL.]

De Roos *et al.* (2003) used pooled data from three case–control studies of NHL conducted in the 1980s in Nebraska (Zahm *et al.*, 1990), Kansas (Hoar *et al.*, 1986), and in Iowa and Minnesota (Cantor *et al.*, 1992) (see the *Monograph* on Malathion, Section 2.0, for a detailed description of these studies) to examine pesticide exposures in farming as risk factors for NHL in men. The study population included 870 cases and 2569 controls; 650 cases and 1933 controls were included for the analysis of 47 pesticides controlling for potential confounding by other pesticides. Both logistic regression and hierarchical regression (adjusted estimates were based on prior distributions for the pesticide effects, which provides more conservative estimates than logistic regression) were used in data analysis, and all models were essentially adjusted for age, study site, and other pesticides. Reported use of glyphosate as well as several individual pesticides was associated with increased incidence of NHL. Based on 36 cases exposed, the odds ratios for the association between exposure to glyphosate and NHL were 2.1 (95% CI, 1.1–4.0) in the logistic regression analyses and 1.6 (95% CI, 0.9–2.8) in the hierarchical regression analysis. [The numbers of cases and controls were lower than those in the pooled analysis by Waddell *et al.* (2001) because only subjects with no missing data on pesticides were included. The strengths of this study when compared with other studies are that it was large,

Table 2.2 Case–control studies of leukaemia and lymphoma and exposure to glyphosate

Reference, location, enrolment period	Population size, description, exposure assessment method	Organ site (ICD code)	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled	Comments
USA							
Brown *et al.* (1990) Iowa and Minnesota, USA 1981–1983	Cases: 578 (340 living, 238 deceased) (response rate, 86%); cancer registry or hospital records Controls: 1245 (820 living, 425 deceased) (response rate, 77–79%); random-digit dialling for those aged < 65 years and Medicare for those aged ≥ 65 years Exposure assessment method: questionnaire	Leukaemia	Any glyphosate	15	0.9 (0.5–1.6)	Age, vital status, state, tobacco use, family history lymphopoietic cancer, high-risk occupations, high risk exposures	[Strengths: large population based study in a farming area. Limitations: not controlled for exposure to other pesticides. Limited power for glyphosate exposure]
Cantor *et al.* (1992) Iowa and Minnesota, USA 1980–1982	Cases: 622 (response rate, 89.0%); Iowa health registry records and Minnesota hospital and pathology records Controls: 1245 (response rate, 76–79%); population-based; no cancer of the lympho-haematopoietic system; frequency-matched to cases by age (5-year group), vital status, state. Random-digit dialling (aged < 65 years); Medicare records (aged ≥ 65 years); state death certificate files (deceased subjects) Exposure assessment method: questionnaire; in-person interview	NHL	Ever handled glyphosate	26	1.1 (0.7–1.9)	Age, vital status, state, smoking status, family history lymphopoietic cancer, high-risk occupations, high-risk exposures	Data subsequentially pooled in De Roos *et al.* (2003); white men only [Strengths: large population-based study in farming areas. Limitations: not controlled for exposure to other pesticides. Limited power for glyphosate exposure]

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Table 2.2 (continued)

Reference, location, enrolment period	Population size, description, exposure assessment method	Organ site (ICD code)	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled	Comments
Brown *et al.* (1993) Iowa, USA 1981–1984	Cases: 173 (response rate, 84%); Iowa health registry Controls: 650 (response rate, 78%); Random-digit dialling (aged < 65 years) and Medicare (aged > 65 years) Exposure assessment method: questionnaire	Multiple myeloma	Any glyphosate	11	1.7 (0.8–3.6)	Age, vital status	[Strengths: population-based study. Areas with high prevalence of farming. Limitations: limited power for glyphosate exposure]
De Roos *et al.* (2003) Nebraska, Iowa, Minnesota, Kansas, USA 1979–1986	Cases: 650 (response rate, 74.7%); cancer registries and hospital records Controls: 1933 (response rate, 75.2%); random-digit dialling, Medicare, state mortality files Exposure assessment method: questionnaire; interview (direct or next-of-kin)	NHL	Any glyphosate exposure	36	2.1 (1.1–4)	Age, study area, other pesticides	Both logistic regression and hierarchical regression were used in data analysis, the latter providing more conservative estimates [Strengths: increased power when compared with other studies, population-based, and conducted in farming areas. Advanced analytical methods to account for multiple exposures] Included participants from Cantor *et al.* (1992), Zahm *et al.* (1990), Hoar *et al.* (1986), and Brown *et al.* (1990)

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Table 2.2 (continued)

Reference, location, enrolment period	Population size, description, exposure assessment method	Organ site (ICD code)	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled	Comments
Lee *et al.* (2004a) Iowa, Minnesota and Nebraska, USA 1980–1986	Cases: 872 (response rate, NR); diagnosed with NHL from 1980 to 1986 Controls: 2381 (response rate, NR); frequency-matched controls Exposure assessment method: questionnaire; information on use of pesticides and history of asthma was based on interviews	NHL	Exposed to glyphosate – non-asthmatics Exposed to glyphosate – asthmatics	53 6	1.4 (0.98–2.1) 1.2 (0.4–3.3)	Age, vital status, state	177 participants (45 NHL cases, 132 controls) reported having been told by their doctor that they had asthma
Canada							
McDuffie *et al.* (2001) Canada 1991–1994	Cases: 517 (response rate, 67.1%), from cancer registries and hospitals Controls: 1506 (response rate, 48%); random sample from health insurance and voting records Exposure assessment method: questionnaire, some administered by telephone, some by post	NHL	Exposed to glyphosate Unexposed > 0 and ≤ 2 days > 2 days	51 464 28 23	1.2 (0.83–1.74) 1 1.0 (0.63–1.57) 2.12 (1.2–3.73)	Age, province of residence	Cross-Canada study [Strengths: large population based study. Limitations: no quantitative exposure data. Exposure assessment by questionnaire. Relatively low participation]

Table 2.2 (continued)

Reference, location, enrolment period	Population size, description, exposure assessment method	Organ site (ICD code)	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled	Comments
Karunanayake *et al.* (2012) Six provinces in Canada (Quebec, Ontario, Manitoba, Saskatchewan, Alberta, and British Columbia) 1991–1994	Incident cases: 316 (response rate, 68.4%); men aged ≥ 19 years; ascertained from provincial cancer registries, except in Quebec (hospital ascertainment) Controls: 1506 (response rate, 48%); matched by age ± 2 years to be comparable with the age distribution of the entire case group (HL, NHL, MM, and STS) within each province of residence. Potential controls (men aged ≥ 19 years) selected at random within age constraints from the provincial health insurance records (Alberta, Saskatchewan, Manitoba, Quebec), computerized telephone listings (Ontario), or voters' lists (British Columbia) Exposure assessment method: questionnaire; stage 1 used a self-administered postal questionnaire; and in stage 2 detailed pesticide exposure information was collected by telephone interview	HL (ICDO2 included nodular sclerosis (M9656/3; M9663/3; M9664/3; M9665/3; M9666/3; M9667/3), lymphocytic predominance (M9651/3; M9657/3; M9658/3; M9659/3), mixed cellularity (M9652/3), lymphocytic depletion (M9653/3; M9654/3), miscellaneous (other M9650-M9669 codes for HL)	Glyphosate-based formulation Glyphosate-based formulation	38 38	1.14 (0.74–1.76) 0.99 (0.62–1.56)	Age group, province of residence Age group, province of residence, medical history	Cross Canada study Based on the statistical analysis of pilot study data, it was decided that the most efficient definition of pesticide exposure was a cumulative exposure ≥ 10 hours/year to any combination of pesticides. This discriminated (a) between incidental, bystander, and environmental exposure vs more intensive exposure, and (b) between cases and controls [Strengths: large study. Limitations: low response rates]

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Table 2.2 (continued)

Reference, location, enrolment period	Population size, description, exposure assessment method	Organ site (ICD code)	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled	Comments
Kachuri *et al.* (2013) Six Canadian provinces (British Columbia, Alberta, Saskatchewan, Manitoba, Ontario and Quebec) 1991–1994	Cases: 342 (response rate, 58%); men aged ≥ 19 years diagnosed between 1991 and 1994 were ascertained from provincial cancer registries except in Quebec, where ascertained from hospitals Controls: 1357 (response rate, 48%); men aged ≥ 19 years selected randomly using provincial health insurance records, random digit dialling, or voters' lists, frequency-matched to cases by age (±2 years) and province of residence Exposure assessment method: questionnaire	Multiple myeloma	Glyphosate use	32	1.19 (0.76–1.87)	Age, province of residence, use of a proxy respondent, smoking status, medical variables, family history of cancer	Cross-Canada study [Strengths: population-based case–control study. Limitations: relatively low response rates]
			Use of glyphosate (> 0 and ≤ 2 days per year)	15	0.72 (0.39–1.32)		
			Use of glyphosate (> 2 days per year)	12	2.04 (0.98–4.23)		
Sweden							
Nordström *et al.* (1998) Sweden 1987–1992	Cases: 111 (response rate, 91%); 121 HCL cases in men identified from Swedish cancer registry Controls: 400 (response rate, 83%); 484 (four controls/case) matched for age and county; national population registry Exposure assessment method: questionnaire; considered exposed if minimum exposure of 1 working day (8 h) and an induction period of at least 1 year	HCL	Exposed to glyphosate	4	3.1 (0.8–12)	Age	Overlaps with Hardell *et al.* (2002). HCL is a subtype of NHL [Strengths: population-based case–control study. Limitations: Limited power. There was no adjustment for other exposures]

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Table 2.2 (continued)

Reference, location, enrolment period	Population size, description, exposure assessment method	Organ site (ICD code)	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled	Comments
Hardell & Eriksson (1999) Northern and middle Sweden 1987–1990	Cases: 404 (192 deceased) (response rate, 91%); regional cancer registries Controls: 741 (response rate, 84%); live controls matched for age and county were recruited from the national population registry, and deceased cases matched for age and year of death were identified from the national registry for causes of death Exposure assessment method: questionnaire	NHL (ICD-9 200 and 202)	Ever glyphosate – univariate Ever glyphosate – multivariate	4 NR	2.3 (0.4–13) 5.8 (0.6–54)	Not specified in the multivariable analysis	Overlaps with Hardell *et al.* (2002) [Strengths: population-based study. Limitations: few subjects were exposed to glyphosate and the study had limited power. Analyses were "multivariate" but covariates were not specified]
Hardell *et al.* (2002) Sweden; four Northern counties and three counties in mid Sweden 1987–1992	Cases: 515 (response rate, 91% in both studies); Swedish cancer registry Controls: 1141 (response rates, 84% and 83%%); national population registry Exposure assessment method: questionnaire	NHL and HCL	Ever glyphosate exposure (univariate) Ever glyphosate exposure (multivariate)	8 8	3.04 (1.08–8.5) 1.85 (0.55–6.2)	Age, county, study site, vital status, other pesticides in the multivariate analysis	Overlaps with Nordström *et al.* (1998) and Hardell & Eriksson (1999). [Strengths: large population-based study. Limitations: limited power for glyphosate exposure]

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Table 2.2 (continued)

Reference, location, enrolment period	Population size, description, exposure assessment method	Organ site (ICD code)	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled	Comments
Eriksson *et al.* (2008) Sweden. Four health service areas (Lund, Linkoping, Orebro and Umea) 1999–2002	Cases: 910 (response rate, 91%); incident NHL cases were enrolled from university hospitals Controls: 1016 (response rate, 92%); national population registry Exposure assessment method: questionnaire	NHL	Any glyphosate	29	2.02 (1.1–3.71)	Age, sex, year of enrolment	[Strengths: population-based case-control. Limitations: limited power for glyphosate]
			Any glyphosate*	29	1.51 (0.77–2.94)		* Exposure to other pesticides (e.g. MPCA) controlled in the analysis
			≤ 10 days per year use	12	1.69 (0.7–4.07)		
			> 10 days per year use	17	2.36 (1.04–5.37)		
		NHL	1–10 yrs	NR	1.11 (0.24–5.08)		
			> 10 yrs	NR	2.26 (1.16–4.4)		
		B-cell lymphoma	Exposure to glyphosate	NR	1.87 (0.998–3.51)		
		Lymphocytic lymphoma/B-CLL	Exposure to glyphosate	NR	3.35 (1.42–7.89)		
		Diffuse large B-cell lymphoma	Exposure to glyphosate	NR	1.22 (0.44–3.35)		
		Follicular, grade I–III	Exposure to glyphosate	NR	1.89 (0.62–5.79)		
		Other specified B-cell lymphoma	Exposure to glyphosate	NR	1.63 (0.53–4.96)		
		Unspecified B-cell lymphoma	Exposure to glyphosate	NR	1.47 (0.33–6.61)		
		T-cell lymphoma	Exposure to glyphosate	NR	2.29 (0.51–10.4)		
		Unspecified NHL	Exposure to glyphosate	NR	5.63 (1.44–22)		

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Table 2.2 (continued)

Reference, location, enrolment period	Population size, description, exposure assessment method	Organ site (ICD code)	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled	Comments
Other studies in Europe							
Orsi *et al.* (2009) France 2000–2004	Cases: 491 (response rate, 95.7%); cases (244 NHL; 87 HL; 104 LPSs; 56 MM) were recruited from main hospitals of the French cities of Brest, Caen, Nantes, Lille, Toulouse and Bordeaux, aged 20–75 years; ALL cases excluded Controls: 456 (response rate, 91.2%); matched on age and sex, recruited in the same hospitals as the cases, mainly in orthopaedic and rheumatological departments and residing in the hospital's catchment area Exposure assessment method: questionnaire	NHL	Any glyphosate exposure	12	1.0 (0.5–2.2)	Age, centre, socioeconomic category (blue/ white collar)	[Limitations: limited power for glyphosate]
		HL	Any exposure to glyphosate	6	1.7 (0.6–5)		
		LPS	Any exposure to glyphosate	4	0.6 (0.2–2.1)		
		MM	Any exposure to glyphosate	5	2.4 (0.8–7.3)		
		All lymphoid neoplasms	Any exposure to glyphosate	27	1.2 (0.6–2.1)		
		NHL, diffuse large cell lymphoma	Occupational use of glyphosate	5	1.0 (0.3–2.7)		
		NHL, follicular lymphoma	Occupational exposure to glyphosate	3	1.4 (0.4–5.2)		
		LPS/CLL	Occupational exposure to glyphosate	2	0.4 (0.1–1.8)		
		LPS/HCL	Occupational exposure to glyphosate	2	1.8 (0.3–9.3)		

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Table 2.2 (continued)

Reference, location, enrolment period	Population size, description, exposure assessment method	Organ site (ICD code)	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled	Comments
Cocco *et al.* (2013) Czech Republic, France, Germany, Italy, Ireland and Spain 1998–2004	Cases: 2348 (response rate, 88%); cases were all consecutive adult patients first diagnosed with lymphoma during the study period, resident in the referral area of the participating centres Controls: 2462 (response rate, 81% hospital; 52% population); controls from Germany and Italy were randomly selected by sampling from the general population and matched to cases on sex, 5-year age-group, and residence area. The rest of the centres used matched hospital controls, excluding diagnoses of cancer, infectious diseases and immunodeficiency diseases Exposure assessment method: questionnaire; support of a crop-exposure matrix to supplement the available information, industrial hygienists and occupational experts in each participating centre reviewed the general questionnaires and job modules to assess exposure to pesticides	B-cell lymphoma	Occupational exposure to glyphosate	4	3.1 (0.6–17.1)	Age, sex, education, centre	EPILYMPH case-control study in six European countries

ALL, acute lymphocytic leukaemia; B-CLL, chronic lymphocytic leukaemia; CLL, chronic lymphocytic leukaemia; HCL, hairy cell leukaemia; HL, Hodgkin lymphoma; LPS, lymphoproliferative syndrome; MCPA, 2-methyl-4-chlorophenoxyacetic acid; MM, multiple myeloma; NHL, non-Hodgkin lymphoma; NR, not reported; ref., reference; STS, soft tissue sarcoma

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population-based, and conducted in farming areas. Potential confounding from multiple exposures was accounted for in the analysis.]

Using the data set of the pooled population-based case–control studies in Iowa, Minnesota, and Nebraska, USA, Lee *et al.* (2004a) investigated whether asthma acts as an effect modifier of the association between pesticide exposure and NHL. The study included 872 cases diagnosed with NHL from 1980 to 1986 and 2381 frequency-matched controls. Information on use of pesticides and history of asthma was based on interviews. A total of 177 subjects (45 cases, 132 controls) reported having been told by their doctor that they had asthma. Subjects with a history of asthma had a non-significantly lower risk of NHL than non-asthmatics, and there was no main effect of pesticide exposure. In general, asthmatics tended to have larger odds ratios associated with exposure to pesticides than non-asthmatics. There was no indication of effect modification: the odds ratio associated with glyphosate use was 1.4 (95% CI, 0.98–2.1; 53 exposed cases) among non-asthmatics and 1.2 (95% CI, 0.4–3.3; 6 exposed cases) for asthmatics, when compared with non-asthmatic non-exposed farmers). [This analysis overlapped with that of De Roos *et al.* (2003).]

(b) *The cross-Canada case–control study*

McDuffie *et al.* (2001) studied the associations between exposure to specific pesticides and NHL in a multicentre population-based study with 517 cases and 1506 controls among men of six Canadian provinces (see the *Monograph* on Malathion, Section 2.0, for a detailed description of this study). Odds ratios of 1.26 (95% CI, 0.87–1.80; 51 exposed cases; adjusted for age and province) and 1.20 (95% CI, 0.83–1.74, adjusted for age, province, high-risk exposures) were observed for exposure to glyphosate. In an analysis by frequency of exposure to glyphosate, participants with > 2 days of exposure per year had an odds ratio of 2.12 (95% CI, 1.20–3.73, 23 exposed cases) compared with those with some, but ≤ 2 days of exposure. [The study was large, but had relatively low participation rates.]

Kachuri *et al.* (2013) investigated the association between lifetime use of pesticides and multiple myeloma in a population-based case–control study among men in six Canadian provinces between 1991 and 1994 (see the *Monograph* on Malathion, Section 2.0, for a detailed description of this study). Data from 342 cases of multiple myeloma and 1357 controls were obtained for ever-use of pesticides, number of pesticides used, and days per year of pesticide use. The odds ratios were adjusted for age, province of residence, type of respondent, smoking and medical history. The odds ratio for ever-use of glyphosate was 1.19 (95% CI, 0.76–1.87; 32 cases). When the analysis was conducted by level of exposure, no association was found for light users (≤ 2 days per year) of glyphosate (OR, 0.72; 95% CI, 0.39–1.32; 15 exposed cases) while the odds ratio in heavier users (> 2 days per year) was 2.04 (95% CI, 0.98–4.23; 12 exposed cases). [The study had relatively low response rates. Multiple myeloma is now considered a subtype of NHL.]

(c) *Case–control studies in Sweden*

Nordström *et al.* (1998) conducted a population case–control study in Sweden on hairy cell leukaemia (considered to be a subgroup of NHL). The study included 121 cases in men and 484 controls matched for age and sex. An age-adjusted odds ratio of 3.1 (95% CI, 0.8–12; 4 exposed cases) was observed for exposure to glyphosate. [This study had limited power to detect an effect, and there was no adjustment for other exposures.]

Hardell & Eriksson (1999) reported the results of a population-based case–control study on the incidence of NHL in men associated with pesticide exposure in four northern counties in Sweden. Exposure data was collected by questionnaire (also supplemented by telephone interviews) from 404 cases (192 deceased) and 741

controls (matched by age, sex, county, and vital status). Increased risks of NHL were found for subjects exposed to herbicides and fungicides. The odds ratio for ever-use of glyphosate was 2.3 (95% CI, 0.4–13; 4 exposed cases) in a univariate analysis, and 5.8 (95% CI, 0.6–54) in a multivariable analysis. [The exposure frequency was low for glyphosate, and the study had limited power to detect an effect. The variables included in the multivariate analysis were not specified. This study may have overlapped partially with those of Hardell *et al.* (2002).]

Hardell *et al.* (2002) conducted a pooled analysis of two case–control studies, one on NHL (already reported in Hardell & Eriksson, 1999) and another on hairy cell leukaemia, a subtype of NHL (already reported by Nordström *et al.*, 1998). The pooled analysis of NHL and hairy cell leukaemia was based on 515 cases and 1141 controls. Increased risk was found for exposure to glyphosate (OR, 3.04; 95% CI, 1.08–8.52; 8 exposed cases) in the univariate analysis, but the odds ratio decreased to 1.85 (95% CI, 0.55–6.20) when study, study area, and vital status were considered in a multivariate analysis. [The exposure frequency was low for glyphosate and the study had limited power. This study partially overlapped with those of Hardell & Eriksson (1999) and Nordström *et al.* (1998).]

Eriksson *et al.* (2008) reported the results of a population based case–control study of exposure to pesticides as a risk factor for NHL. Men and women aged 18–74 years living in Sweden were included from 1 December 1999 to 30 April 2002. Incident cases of NHL were enrolled from university hospitals in Lund, Linköping, Örebro, and Umeå. Controls (matched by age and sex) were selected from the national population registry. Exposure to different agents was assessed by questionnaire. In total, 910 (91%) cases and 1016 (92%) controls participated. Multivariable models included agents with statistically significant increased odds ratios (MCPA, 2-methyl-4-chlorophenoxyacetic acid), or with an odds ratio of > 1.50 and at least 10 exposed subjects (2,4,5-T and/or 2,4-D; mercurial seed dressing, arsenic, creosote, tar), age, sex, year of diagnosis or enrolment. The odds ratio for exposure to glyphosate was 2.02 (95% CI, 1.10–3.71) in a univariate analysis, and 1.51 (95% CI, 0.77–2.94) in a multivariable analysis. When exposure for more than 10 days per year was considered, the odds ratio was 2.36 (95% CI, 1.04–5.37). With a latency period of > 10 years, the odds ratio was 2.26 (95% CI, 1.16–4.40). The associations with exposure to glyphosate were reported also for lymphoma subtypes, and elevated odds ratios were reported for most of the cancer forms, including B-cell lymphoma (OR, 1.87; 95% CI, 0.998–3.51) and the subcategory of small lymphocytic lymphoma/chronic lymphocytic leukaemia (OR, 3.35; 95% CI, 1.42–7.89; [not adjusted for other pesticides]). [This was a large study; there was possible confounding from use of other pesticides including MCPA, but this was considered in the analysis.]

(d) Other case–control studies in Europe

Orsi *et al.* (2009) reported the results of a hospital-based case–control study conducted in six centres in France between 2000 and 2004. Incident cases with a diagnosis of lymphoid neoplasm aged 20–75 years and controls of the same age and sex as the cases were recruited in the same hospital, mainly in the orthopaedic and rheumatological departments during the same period. [The Working Group noted that the age of case eligibility was given in the publication as 20–75 years in the materials and methods section, but as 18–75 years in the abstract.] Exposures to pesticides were evaluated through specific interviews and case-by-case expert reviews. The analyses included 491 cases (244 cases of NHL, 87 cases of Hodgkin lymphoma), 104 of lymphoproliferative syndrome, and 56 cases of multiple myeloma), and 456 age- and sex-matched controls. Positive associations between some subtypes and occupational exposure to several pesticides

were noted. The odds ratios associated with any exposure to glyphosate were 1.2 (95% CI, 0.6–2.1; 27 exposed cases) for all lymphoid neoplasms combined, 1.0 (95% CI, 0.5–2.2; 12 exposed cases) for NHL, 0.6 (95% CI, 0.2–2.1; 4 exposed cases) for lymphoproliferative syndrome, 2.4 (95% CI, 0.8–7.3) for multiple myeloma, and 1.7 (95% CI, 0.6–5.0; 6 exposed cases) for Hodgkin lymphoma, after adjusting for age, centre, and socioeconomic category ("blue/white collar").

Cocco *et al.* (2013) reported the results of a pooled analysis of case–control studies conducted in six European countries in 1998–2004 (EPILYMPH, Czech Republic, France, Germany, Ireland, Italy, and Spain) to investigate the role of occupational exposure to specific groups of chemicals in the etiology of lymphoma overall, B-cell lymphoma, and its most prevalent subtypes. A total of 2348 incident cases of lymphoma and 2462 controls were recruited. Controls from Germany and Italy were randomly selected by sampling from the general population, while the rest of the centres used matched hospital controls. Overall, the participation rate was 88% for cases, 81% for hospital controls, and 52% for population controls. An occupational history was collected with farm work-specific questions on type of crop, farm size, pests being treated, type and schedule of pesticide use. In each study centre, industrial hygienists and occupational experts assessed exposure to specific groups of pesticides and individual compounds with the aid of agronomists. [Therefore any exposure misclassification would be non-differential.] Analyses were conducted for lymphoma and the most prevalent lymphoma subtypes adjusting for age, sex, education, and centre. Lymphoma overall, and B-cell lymphoma were not associated with any class of the investigated pesticides, while the risk of chronic lymphocytic leukaemia was elevated among those ever exposed to inorganic and organic pesticides. Only for a few individual agrochemicals was there a sizeable number of study subjects to conduct a meaningful analysis, and the odds ratio for exposure to glyphosate and B-cell lymphoma was 3.1 (95% CI, 0.6–17.1; 4 exposed cases and 2 exposed controls). [The study had a very limited power to assess the effects of glyphosate on risk of NHL.]

2.2.2 Other haematopoietic cancers

Orsi *et al.* (2009) also reported results for Hodgkin lymphoma (see Section 2.2.1).

Karunanayake *et al.* (2012) conducted a case–control study of Hodgkin lymphoma among white men, aged 19 years or older, in six regions of Canada (see the Malathion *Monograph*, Section 2.0, for a detailed description of this study). The analysis included 316 cases and 1506 age-matched (± 2 years) controls. Based on 38 cases exposed to glyphosate, the odds ratios were 1.14 (95% CI, 0.74–1.76) adjusted for age and province, and 0.99 (95% CI, 0.62–1.56) when additionally adjusted for medical history variables.

Brown *et al.* (1990) evaluated exposure to carcinogens in an agricultural setting and the relationship with leukaemia in a population-based case–control interview study in Iowa and Minnesota, USA, including 578 white men with leukaemia and 1245 controls. The exposure assessment was done with a personal interview of the living subjects or the next-of-kin. Farmers had a higher risk of all leukaemias compared with non-farmers, and associations were found for exposure to specific animal insecticides, including the organophosphates crotoxyphos, dichlorvos, famphur, pyrethrins, and methoxychlor. The odds ratio for glyphosate was 0.9 (95% CI, 0.5–1.6; 15 exposed cases; adjusted for vital status, age, state, tobacco use, family history of lymphopoietic cancer, high-risk occupations, and high-risk exposures). [This was a large study in an agricultural setting, but had limited power for studying the effects of glyphosate use.]

2.3 Case–control studies on other cancer sites

2.3.1 Cancer of the oesophagus and stomach

Lee *et al.* (2004b) evaluated the risk of adenocarcinomas of the oesophagus and stomach associated with farming and agricultural pesticide use. The population-based case–control study was conducted in eastern Nebraska, USA. Subjects of both sexes diagnosed with adenocarcinoma of the stomach (n = 170) or oesophagus (n = 137) between 1988 and 1993 were enrolled. Controls (n = 502) were randomly selected from the population registry of the same geographical area. The response rates were 79% for cancer of the stomach, 88% for cancer of the oesophagus, and 83% for controls. Adjusted odds ratios were estimated for use of individual and chemical classes of insecticides and herbicides, with non-farmers as the reference category. No association was found with farming or ever-use of insecticides or herbicides, or with individual pesticides. For ever-use of glyphosate, the odds ratio was 0.8 (95% CI, 0.4–1.4; 12 exposed cases) for cancer of the stomach, and 0.7 (95% CI, 0.3–1.4; 12 exposed cases) for oesophageal cancer. [The study was conducted in a farming area, but the power to detect an effect of glyphosate use was limited.]

2.3.2 Cancer of the brain

Ruder *et al.* (2004) conducted a case–control study on glioma among nonmetropolitan residents of Iowa, Michigan, Minnesota, and Wisconsin in the Upper Midwest Health Study, USA. The study included 457 cases of glioma and 648 population-based controls, all adult men. Exposure assessment was done with interviews of the subject or the relatives. The response rates were 93% and 70% for cases and controls, respectively. No association were found with any of the pesticides assessed, including glyphosate. [Glyphosate use was assessed, but specific results were not presented.]

Carreón *et al.* (2005) evaluated the effects of rural exposures to pesticides on risk of glioma among women aged 18–80 years who were nonmetropolitan residents of Iowa, Michigan, Minnesota, and Wisconsin in the Upper Midwest Health Study, USA. A total of 341 cases of glioma and 528 controls were enrolled. A personal interview was carried out for exposure assessment. The response rates were 90% and 72%, respectively. After adjusting for age, age group, education, and farm residence, no association with glioma was observed for exposure to several pesticide classes or individual pesticides. There was a reduced risk for glyphosate (OR, 0.7; 95% CI, 0.4–1.3; 18 exposed cases). These results were not affected by the exclusion of proxy respondents (43% of cases, 2% of controls).

Lee *et al.* (2005) evaluated the association between farming and agricultural pesticide use and risk of adult glioma in a population-based case–control study in eastern Nebraska, USA. Cases of glioma were in men and women (n = 251) and were compared with population controls from a previous study (n = 498). A telephone interview was conducted for 89% of the cases and 83% of the controls. Adjusted odds ratios for farming and for use of individual and chemical classes of insecticides and herbicides were calculated using non-farmers as the reference category. Among men, ever living or working on a farm and duration of farming were associated with significantly increased risks of glioma, but the positive findings were limited to proxy respondents. Among women, there were no positive associations with farming activities among self or proxy respondents. Some specific pesticide families and individual pesticides were associated with significantly increased risks among male farmers, but most of the positive associations were limited to proxy respondents. There was a non-significant excess risk with glyphosate use for the overall group (OR, 1.5; 95% CI, 0.7–3.1; 17 exposed cases), but there was inconsistency between observations for self-respondents (OR,

0.4; 95% CI, 0.1–1.6) and observations for proxy respondents (OR, 3.1; 95% CI, 1.2–8.2). [The study had limited power to detect an effect of glyphosate use, and the inconsistencies for self and proxy respondents made the results difficult to interpret.]

2.3.3 Soft tissue sarcoma

Pahwa *et al.* (2011) reported the results of the soft tissue sarcoma component of the cross-Canada study in relation to specific pesticides, including 357 cases of soft tissue sarcoma and 1506 population controls from 1991–1994. The fully adjusted odds ratio for glyphosate use was 0.90 (95% CI, 0.58–1.40).

2.3.4 Cancer of the prostate

Band *et al.* (2011) report results of a case–control study including 1516 patients with cancer of the prostate (ascertained by the cancer registry of British Columbia, Canada, for 1983–90) and 4994 age-matched controls with cancers at all other cancer sites excluding lung and unknown primary site. Agricultural exposures were assessed by job-exposure matrix. A total of 60 cases were exposed to glyphosate (adjusted OR, 1.36; 95% CI, 0.83–2.25).

2.3.5 Childhood cancer

Parental exposure to pesticides, including glyphosate, was assessed in a population-based case–control study of childhood leukaemia in Costa Rica (Monge *et al.*, 2007). However, associations of childhood cancer with glyphosate were reported only for an "other pesticides" category that also included paraquat, chlorothalonil, and other chemicals. [Because glyphosate was not specifically assessed, this study was not evaluated by the Working Group.]

2.4. Meta-analyses

Schinasi & Leon (2014) conducted a systematic review and meta-analysis of NHL and occupational exposure to agricultural pesticides, including glyphosate. The meta-analysis for glyphosate included six studies (McDuffie *et al.*, 2001; Hardell *et al.*, 2002; De Roos *et al.*, 2003; 2005a; Eriksson *et al.*, 2008; Orsi *et al.*, 2009) and yielded a meta risk-ratio of 1.5 (95% CI, 1.1–2.0). [The Working Group noted that the most fully adjusted risk estimates from the articles by Hardell *et al.* (2002) and Eriksson *et al.* (2008) were not used in this analysis. After considering the adjusted estimates of the two Swedish studies in the meta-analysis, the Working Group estimated a meta risk-ratio of 1.3 (95% CI, 1.03–1.65), $I^2 = 0\%$, P for heterogeneity 0.589.]

3. Cancer in Experimental Animals

3.1 Mouse

See Table 3.1

3.1.1 Dietary administration

Groups of 50 male and 50 female CD-1 mice [age not reported] were given diets containing glyphosate (purity, 99.7%) at a concentration of 0, 1000, 5000, or 30 000 ppm, ad libitum, for 24 months. There was no treatment-related effect on body weight in male and female mice at the lowest or intermediate dose. There was a consistent decrease in body weight in the male and female mice at the highest dose compared with controls. Survival in all dose groups was similar to that of controls. There was a positive trend ($P = 0.016$, trend test; see EPA, 1985b) in the incidence of renal tubule adenoma in dosed male mice: 0/49, 0/49, 1/50 (2%), 3/50 (6%). [The Working Group noted that renal tubule adenoma is a rare tumour in CD-1 mice.] No data on tumours of the kidney

Table 3.1 Studies of carcinogenicity with glyphosate in mice

Species, strain (sex) Duration Reference	Dosing regimen, Animals/group at start	For each target organ: incidence (%) and/or multiplicity of tumours	Significance	Comments
Mouse, CD-1 (M, F) 24 mo EPA (1985a, b, 1986, 1991a)	Diet containing glyphosate (technical grade; purity, 99.7%) at concentrations of 0, 1000, 5000, or 30 000 ppm, ad libitum, for 24 mo 50 M and 50 F/group [age, NR]	*Males* Renal tubule adenoma: 0/49, 0/49, 1/50 (2%), 3/50 (6%) *Females* No data provided on the kidney	*P* for trend = 0.016; see Comments	No information was provided on renal tubule adenomas in female mice, or on statistical analyses of tumour data EPA recommended that additional renal sections be cut and evaluated from all control and treated male mice. The pathology report for these additional sections (EPA, 1985b) showed the same incidence of renal tubule adenomas as originally reported, with no significant difference in incidence when comparing control and treated groups; however, the test for linear trend in proportions resulted in *P* = 0.016 EPA (1986) convened a PWG and requested additional pathological and statistical information on kidney tumours observed in male mice treated with glyphosate
		Report from the PWG of the EPA (1986): *Males* Renal tubule adenoma: 1/49 (2%), 0/49, 0/50, 1/50 (2%)	[NS]	
		Renal tubule carcinoma: 0/49, 0/49, 1/50 (2%), 2/50 (4%)	[*P* = 0.037; Cochran–Armitage trend test]	
		Renal tubule adenoma or carcinoma (combined): 1/49 (2%), 0/49, 1/50 (2%), 3/50 (6%)	[*P* = 0.034; Cochran–Armitage trend test]	
Mouse, CD-1 (M, F) 104 wk IMPR (2006)	Diet containing glyphosate (purity, 98.6%) at doses of 0, 100, 300, 1000 mg/kg bw, ad libitum, for 104 wk 50 M and 50 F/group [age, NR]	*Males* Haemangiosarcoma: 0/50, 0/50, 0/50, 4/50 (8%)	[*P* < 0.001; Cochran–Armitage trend test]	
		Histiocytic sarcoma in the lymphoreticular/haemopoietic tissue: 0/50, 2/50 (4%), 0/50, 2/50 (4%)	NS	
		Females Haemangiosarcoma: 0/50, 2/50 (4%), 0/50, 1/50 (2%)	NS	
		Histiocytic sarcoma in the lymphoreticular/haemopoietic tissue: 0/50, 3/50 (6%), 3/50 (6%), 1/50 (2%)	NS	

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Table 3.1 (continued)

Species, strain (sex) Duration Reference	Dosing regimen, Animals/group at start	For each target organ: incidence (%) and/or multiplicity of tumours	Significance	Comments
Mouse, Swiss (M) 32 wk George *et al.* (2010)	Initiation–promotion study Skin application of glyphosate-based formulation (glyphosate, 41%; POEA, ~15%) (referred to as "glyphosate") dissolved in 50% ethanol; DMBA dissolved in 50% ethanol, and TPA dissolved in 50% acetone, used in the groups described below 20 M/group	Skin tumours [called "papillomas" by the authors, following gross examination only]		Short duration of treatment, no solvent controls, and lack of any histopathological evaluation Age at start, NR (mice weighed 12–15 g bw) [The Working Group concluded this was an inadequate study for the evaluation of glyphosate]
	Group I: untreated control (no treatment)	Group I: 0/20		
	Group II: glyphosate only: 25 mg/kg bw topically, 3 × /wk, for 32 wk	Group II: 0/20		
	Group III: single topical application of DMBA, 52 µg/mouse, followed 1 wk later by TPA, 5 µg/mouse, 3 × /wk, for 32 wk	Group III: 20/20*, 7.8 ± 1.1	*$P < 0.05$ vs groups VI and VII	
	Group IV: single topical application of glyphosate, 25 mg/kg bw, followed 1 wk later by TPA, 5 µg/mouse, 3 × /wk, for 32 wk	Group I: 0/20		
	Group V: 3 × /wk topical application of glyphosate, 25 mg/kg bw, for 3 wk, followed 1 wk later by TPA, 5 µg/mouse, 3 × /wk, for 32 wk	Group V: 0/20		
	Group VI: single topical application of DMBA, 52 µg/mouse	Group VI: 0/20		
	Group VII: topical application of TPA, 5 µg/mouse, 3 × /wk, for 32 wk	Group VII: 0/20		
	Group VIII: single topical application of DMBA, 52 µg/mouse, followed 1 wk later by topical treatment with glyphosate, 25 mg/kg bw, 3 × /wk, for 32 wk	Group VIII: 8/20*, 2.8 ± 0.9	*$P < 0.05$ vs group VI	

bw, body weight; DMBA, 7,12-dimethylbenz[*a*]anthracene; EPA, United States Environmental Protection Agency; F, female; M, male; mo, month; NR, not reported; NS, not significant; POEA, polyethoxylated tallowamine; PWG, pathology working group; TPA, 12-*O*-tetradecanoyl-phorbol-13-acetate; vs, versus; wk, week; yr, year

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were provided for female mice. No other tumour sites were identified (EPA, 1985a). Subsequent to its initial report (EPA, 1985a), the United States Environmental Protection Agency (EPA) recommended that additional renal sections be cut and evaluated from all male mice in the control and treated groups. The pathology report for these additional sections (EPA, 1985b) indicated the same incidence of renal tubule adenoma as originally reported, with no significant increase in incidence between the control group and treated groups by pairwise comparison. However, as already reported above, the test for linear trend in proportions resulted in a significance of $P = 0.016$. The EPA (1986) also requested that a pathology working group (PWG) be convened to evaluate the tumours of the kidney observed in male mice treated with glyphosate, including the additional renal sections. In this second evaluation, the PWG reported that the incidence of adenoma of the renal tubule was 1/49 (2%), 0/49, 0/50, 1/50 (2%) [not statistically significant]; the incidence of carcinoma of the renal tubule was 0/49, 0/49, 1/50 (2%), 2/50 (4%) [$P = 0.037$, trend test for carcinoma]; and the incidence of adenoma or carcinoma (combined) of the renal tubule was 1/49 (2%), 0/49, 1/50 (2%), 3/50 (6%) [$P = 0.034$, trend test for combined]. [The Working Group considered that this second evaluation indicated a significant increase in the incidence of rare tumours, with a dose-related trend, which could be attributed to glyphosate. Chandra & Frith (1994) reported that only 1 out of 725 [0.14%] CD-1 male mice in their historical database had developed renal cell tumours (one carcinoma).]

[The Working Group noted the differences in histopathological diagnosis between pathologists. Proliferative lesions of the renal tubules are typically categorized according to published criteria as hyperplasia, adenoma, or carcinoma. The difference is not trivial, because focal hyperplasia, a potentially preneoplastic lesion, should be carefully differentiated from the regenerative changes of the tubular epithelium. There is a morphological continuum in the development and progression of renal neoplasia. Thus larger masses may exhibit greater heterogeneity in histological growth pattern, and cytologically more pleomorphism and atypia than smaller lesions (Eustis *et al.*, 1994). Of note, a renal tumour confirmed by the PWG after re-evaluation of the original slides (EPA, 1986), had not been seen in the re-sectioned kidney slides (EPA, 1985b). This may be related to the growth of tumour that – in contrast to tumours in other organs – is not spherical but elliptical because of the potential expansion in tubules. In addition, the concept of tubular expansion without compression of adjacent parenchyma may be at the basis of the discrepancy between the first (EPA, 1985a, b) and second evaluation (EPA, 1986).]

In another study reported to the Joint FAO/WHO Meeting on Pesticide Residues (JMPR), groups of 50 male and 50 female CD-1 mice [age at start not reported] were given diets containing glyphosate (purity, 98.6%) at a concentration that was adjusted weekly for the first 13 weeks and every 4 weeks thereafter to give doses of 0, 100, 300, or 1000 mg/kg bw, ad libitum, for 104 weeks (JMPR, 2006). There was no treatment-related effect on body weight or survival in any of the dosed groups. There was an increase in the incidence of haemangiosarcoma in males – 0/50, 0/50, 0/50, 4/50 (8%) [$P < 0.001$, Cochran–Armitage trend test], and in females – 0/50, 2/50 (4%), 0/50, 1/50 (2%) [not statistically significant], and an increase in the incidence of histiocytic sarcoma in the lymphoreticular/haemopoietic tissue in males – 0/50, 2/50 (4%), 0/50, 2/50 (4%), and in females – 0/50, 3/50 (6%), 3/50 (6%), 1/50 (2%) [not statistically significant for males or females]. [The Working Group considered that this study was adequately reported.]

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3.1.2 Initiation–promotion

Groups of 20 male Swiss mice [age at start not reported; body weight, 12–15 g] were given a glyphosate-based formulation (glyphosate, 41%; polyethoxylated tallowamine, ~15%) (referred to as glyphosate in the article) that was dissolved in 50% ethanol and applied onto the shaved back skin (George *et al.*, 2010). Treatment groups were identified as follows:

- Group I – untreated control;
- Group II – glyphosate only (25 mg/kg bw), applied topically three times per week for 32 weeks;
- Group III – single topical application of dimethylbenz[*a*]anthracene (DMBA; in ethanol; 52 µg/mouse), followed 1 week later by 12-*O*-tetradecanoylphorbol-13-acetate (TPA; in acetone; 5 µg/mouse), applied topically three times per week for 32 weeks;
- Group IV – single topical application of glyphosate (25 mg/kg bw) followed 1 week later by TPA (in acetone; 5 µg/mouse), applied topically three times per week for 32 weeks;
- Group V – glyphosate (25 mg/kg bw) applied topically three times per week for 3 weeks (total of nine applications), followed 1 week later by TPA (in acetone; 5 µg/mouse), applied topically three times per week for 32 weeks;
- Group VI – single topical application of DMBA (in ethanol; 52 µg/mouse);
- Group VII –TPA (in acetone; 5 µg/mouse), applied topically three times per week for 32 weeks; and
- Group VIII –single topical application of DMBA (in ethanol; 52 µg/mouse), followed 1 week later by glyphosate (25 mg/kg bw), applied topically three times per week for 32 weeks.

All mice were killed at 32 weeks. Skin tumours were observed only in group III (positive control, DMBA + TPA, 20/20) and group VIII (DMBA + glyphosate, 8/20; $P < 0.05$ versus group VI [DMBA only, 0/20]). No microscopic examination was conducted and tumours were observed "as a minute wart like growth [that the authors called squamous cell papillomas], which progressed during the course of experiment." [The glyphosate formulation tested appeared to be a tumour promoter in this study. The design of the study was poor, with short duration of treatment, no solvent controls, small number of animals, and lack of histopathological examination. The Working Group concluded that this was an inadequate study for the evaluation of glyphosate.]

3.1.3 Review articles

Greim *et al.* (2015) have published a review article containing information on five long-term bioassay feeding studies in mice. Of these studies, one had been submitted for review to the EPA (EPA, 1985a, b, 1986, 1991a), and one to the JMPR (JMPR, 2006); these studies are discussed in Section 3.1.1. The review article reported on an additional three long-term bioassay studies in mice that had not been previously available in the open literature, but had been submitted to various organizations for registration purposes. The review article provided a brief summary of each study and referred to an online data supplement containing the original data on tumour incidence from study reports. The three additional long-term bioassay studies in mice are summarized below. [The Working Group was unable to evaluate these studies, which are not included in Table 3.1 and Section 5.3, because the information provided in the review article and its supplement was insufficient (e.g. information was lacking on statistical methods, choice of doses, body-weight gain, survival data, details of histopathological examination, and/or stability of dosed feed mixture).]

In the first study (identified as Study 12, 1997a), groups of 50 male and 50 female CD-1

mice [age at start not reported] were given diets containing glyphosate (purity, 94–96%) at a concentration of 0, 1600, 8000, or 40 000 ppm for 18 months. The increase in the incidence of bronchiolo-alveolar adenoma and carcinoma, and of lymphoma, was reported to be not statistically significant in males and females receiving glyphosate. [The Working Group was unable to evaluate this study because of the limited experimental data provided in the review article and supplemental information.]

In the second study (identified as Study 13, 2001), groups of 50 male and 50 female Swiss albino mice [age at start not reported] were given diets containing glyphosate (purity, > 95%) at a concentration of 0 (control), 100, 1000, or 10 000 ppm for 18 months. The authors reported a statistically significant increase in the incidence of malignant lymphoma (not otherwise specified, NOS) in males at the highest dose: 10/50 (20%), 15/50 (30%), 16/50 (32%), 19/50 (38%; $P < 0.05$; pairwise test); and in females at the highest dose: 18/50 (36%), 20/50 (40%), 19/50 (38%), 25/50 (50%; $P < 0.05$; pairwise test). [The Working Group was unable to evaluate this study because of the limited experimental data provided in the review article and supplemental information.]

In the third study (identified as Study 14, 2009a), groups of 51 male and 51 female CD-1 mice [age at start not reported] were given diets containing glyphosate (purity, 94.6–97.6%) at a concentration of 0, 500, 1500, or 5000 ppm for 18 months. Incidences for bronchiolo-alveolar adenoma and carcinoma, malignant lymphoma (NOS), and hepatocellular adenoma and carcinoma in males, and for bronchiolo-alveolar adenoma and carcinoma, malignant lymphoma (NOS) and pituitary adenoma in females, were included in the article. In males, the authors reported that there was a significant positive trend [statistical test not specified] in the incidence of bronchiolo-alveolar carcinoma (5/51, 5/51, 7/51, 11/51) and of malignant lymphoma (0/51, 1/51, 2/51, 5/51). [The Working Group was unable to evaluate this study because of the limited experimental data provided in the review article and supplemental information.]

3.2 Rat

See Table 3.2

3.2.1 Drinking-water

Groups of 10 male and 10 female Sprague-Dawley rats (age, 5 weeks) were given drinking-water containing a glyphosate-based formulation at a dose of 0 (control), 1.1×10^{-8}% (5.0×10^{-5} mg/L), 0.09% (400 mg/L) or 0.5% (2.25×10^{3} mg/L), ad libitum, for 24 months (Séralini *et al.*, 2014). [The study reported is a life-long toxicology study on a glyphosate-based formulation and on genetically modified NK603 maize, which the authors stated was designed as a full study of long-term toxicity and not a study of carcinogenicity. No information was provided on the identity or concentration of other chemicals contained in this formulation.] Survival was similar in treated and control rats. [No data on body weight were provided.] In female rats, there was an almost twofold increase in the incidence of tumours of the mammary gland (mainly fibroadenoma and adenocarcinoma) in animals exposed to the glyphosate-based formulation only versus control animals: control, 5/10 (50%); lowest dose, 9/10 (90%); intermediate dose, 10/10 (100%) [$P < 0.05$; Fisher exact test]; highest dose, 9/10 (90%). [The Working Group concluded that this study conducted on a glyphosate-based formulation was inadequate for evaluation because the number of animals per group was small, the histopathological description of tumours was poor, and incidences of tumours for individual animals were not provided.]

In another study with drinking-water, Chruscielska *et al.* (2000) gave groups of 55 male and 55 female Wistar rats (age, 6–7 weeks) drinking-water containing an ammonium salt

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of glyphosate as a 13.85% solution [purity of glyphosate, not reported] that was used to make aqueous solutions of 0 (control), 300, 900, and 2700 mg/L, for 24 months [details on the dosing regimen were not reported]. The authors reported that survival and body-weight gain were similar in treated and control animals. No significant increase in tumour incidence was reported in any of the treated groups. [The Working Group noted the limited information provided on dosing regimen, histopathological examination method, and tumour incidences.]

3.2.2 Dietary administration

The JMPR report included information on a 1-year feeding study in which groups of 24 male and 24 female Wistar-Alpk:APfSD rats [age at start not reported] were given diets containing glyphosate (purity, 95.6%) at a concentration of 0, 2000, 8000, or 20 000 ppm, ad libitum, for 1 year (JMPR, 2006). There was a treatment-related decrease in body-weight gain at the two highest doses (significant at 20 000 ppm for both sexes, and at 8000 ppm only in females). There was no treatment-related decrease in survival. No significant increase in tumour incidence was observed in any of the treated groups. [The Working Group noted the short duration of exposure.]

The JMPR report also included information on a 104-week feeding study in which groups of 50 male and 50 female Sprague-Dawley rats [age at start not reported] were given diets containing glyphosate (purity, 98.7–98.9%) at a concentration that was adjusted to provide doses of 0, 10, 100, 300, or 1000 mg/kg bw, ad libitum, for 104 weeks (JMPR, 2006). There was a treatment-related decrease in body-weight gain in males and females at the highest dose. There was no significant treatment-related decrease in survival or increase in tumour incidence in any of the treated groups.

Information was also included in the JMPR report on a 24-month feeding study in which groups of 52 male and 52 female Wistar-Alpk:APfSD rats [age at start not reported] were given diets containing glyphosate (purity, 97.6%) at a concentration of 0, 2000, 6000, or 20 000 ppm, ad libitum, for 24 months (JMPR, 2006). There was a treatment-related decrease in body-weight gain in males and females at the highest dose, and a corresponding significant increase in survival in males. No significant increase in tumour incidence was observed in any of the treated groups.

The EPA (1991a, b, c, d) provided information on a long-term study in which groups of 60 male and 60 female Sprague-Dawley rats (age, 8 weeks) were given diets containing glyphosate (technical grade; purity, 96.5%) at a concentration of 0 ppm, 2000 ppm, 8000 ppm, or 20 000 ppm, ad libitum, for 24 months. Ten animals per group were killed after 12 months. There was no compound-related effect on survival, and no statistically significant decreases in body-weight gain in male rats. In females at the highest dose, body-weight gain was significantly decreased, starting on day 51. In males at the lowest dose, there was a statistically significant increase in the incidence of pancreatic islet cell adenoma compared with controls: 8/57 (14%) versus 1/58 (2%), $P \leq 0.05$ (Fisher exact test). Additional analyses by the EPA (1991a) (using the Cochran–Armitage trend test and Fisher exact test, and excluding rats that died or were killed before week 55) revealed a statistically significant higher incidence of pancreatic islet cell adenoma in males at the lowest and highest doses compared with controls: lowest dose, 8/45 (18%; $P = 0.018$; pairwise test); intermediate dose, 5/49 (10%); highest dose, 7/48 (15%; $P = 0.042$; pairwise test) versus controls, 1/43 (2%). The range for historical controls for pancreatic islet cell adenoma reported in males at this laboratory was 1.8–8.5%. [The Working Group noted that there was no statistically significant positive trend in the incidence of these tumours, and no apparent progression to carcinoma.] There was also a statistically significant positive trend in the incidence of hepatocellular adenoma in

Table 3.2 Studies of carcinogenicity with glyphosate in rats

Species, strain (sex) Duration Reference	Dosing regimen, Animals/group at start	For each target organ: incidence (%) and/or multiplicity of tumours	Significance	Comments
Rat, Sprague-Dawley (M, F) 24 mo Séralini *et al.* (2014)	Drinking-water containing a glyphosate-based formulation at a concentration of 0 (control), 1.1×10^{-8}% (glyphosate, 5.0×10^{-5} mg/L), 0.09% (glyphosate, 400 mg/L) or 0.5% (glyphosate, 2.25×10^{3} mg/L), ad libitum, for 24 mo 10 M and 10 F/group (age, 5 wk)	*Males* No significant increase in tumour incidence observed in any of the treated groups *Females* Mammary tumours (mainly fibroadenomas and adenocarcinomas): 5/10 (50%), 9/10 (90%), 10/10 (100%)*, 9/10 (90%) Pituitary lesions (hypertrophy, hyperplasia, and adenoma): 6/10 (60%), 8/10 (80%), 7/10 (70%), 7/10 (70%)	NS *[$P < 0.05$] [NS]	Data are from an in-depth life-long toxicology study on a glyphosate-based formulation and NK603 genetically modified maize; authors stated that the study was designed as a full chronic toxicity and not a carcinogenicity study. No information provided on the identity or concentration of other chemicals contained in this formulation Histopathology poorly described and tumour incidences for individual animals not discussed in detail. Small number of animals per group [The Working Group concluded this was an inadequate study for the evaluation of glyphosate carcinogenicity]
Rat, Wistar (M, F) 24 mo Chruscielska *et al.* (2000)	Drinking-water containing ammonium salt of glyphosate (13.85% solution) [purity of glyphosate, NR] was used to make aqueous solutions of 0, 300, 900, and 2700 mg/L [Details on dosing regimen, NR] 55 M and 55 F/group (age, 6–7 wk)	No significant increase in tumour incidence observed in any of the treated groups	NS	Limited information on dosing regimen, histopathological examination methods, and tumour incidences
Rat, Wistar-Alpk:APfSD (M, F) 1 yr JMPR (2006)	Diet containing glyphosate (purity, 95.6%) at concentrations of 0, 2000, 8000, or 20 000 ppm, ad libitum, for 1 yr 24 M and 24 F/group [age, NR]	No significant increase in tumour incidence observed in any groups of treated animals	NS	Short duration of exposure
Rat, Sprague-Dawley (M, F) 104 wk JMPR (2006)	Diet containing glyphosate (purity, 98.7–98.9%) at doses of 0, 10, 100, 300, or 1000 mg/kg bw, ad libitum, for 104 wk 50 M and 50 F/group [age, NR]	No significant increase in tumour incidence observed in any groups of treated animals	NS	
Rat, Wistar-Alpk:APfSD (M, F) 24 mo JMPR (2006)	Diet containing glyphosate (purity, 97.6%) at concentrations of 0, 2000, 6000, or 20 000 ppm, ad libitum, for 2 yr 52 M and 52 F/group [age, NR]	No significant increase in tumour incidence observed in any groups of treated animals	NS	

Table 3.2 (continued)

Species, strain (sex) Duration Reference	Dosing regimen, Animals/group at start	For each target organ: incidence (%) and/or multiplicity of tumours	Significance	Comments
Rat Sprague-Dawley (M, F) 24 mo EPA (1991a, b, c, d)	Diet containing glyphosate (technical grade; purity, 96.5%) at concentrations of 0, 2000, 8000, or 20 000 ppm, ad libitum, for 24 mo 60 M and 60 F/group (age, 8 wk) 10 rats/group killed after 12 mo	*Males* *Pancreas (islet cell):* Adenoma: 1/58 (2%), 8/57 (14%)*, 5/60 (8%), 7/59 (12%) Carcinoma: 1/58 (2%), 0/57, 0/60, 0/59 Adenoma or carcinoma (combined): 2/58 (3%), 8/57 (14%), 5/60 (8%), 7/59 (12%) *Liver:* Hepatocellular adenoma: 2/60 (3%), 2/60 (3%), 3/60 (6%), 7/60 (12%) Hepatocellular carcinoma: 3/60 (5%), 2/60 (3%), 1/60 (2%), 2/60 (3%) *Females* *Pancreas (islet cell):* Adenoma: 5/60 (8%), 1/60 (2%), 4/60 (7%), 0/59 Carcinoma: 0/60, 0/60, 0/60, 0/59 Adenoma or carcinoma (combined): 5/60 (8%), 1/60 (2%), 4/60 (7%), 0/59 *Thyroid:* C-cell adenoma: 2/60 (3%), 2/60 (3%), 6/60 (10%), 6/60 (10%) C-cell carcinoma: 0/60, 0/60, 1/60, 0/60	Adenoma, * $P \leq 0.05$ (Fisher exact test with Bonferroni inequality); see comments Adenoma, P for trend = 0.016; see comments NS Adenoma, P for trend = 0.031; see comments	Historical control range for pancreatic islet cell adenoma reported in males at this laboratory, 1.8–8.5% EPA (1991a) performed additional analyses using the Cochran–Armitage trend test and Fisher exact test, and excluding animals that died or were killed before wk 54–55: *Males* *Pancreas (islet cell):* Adenoma: 1/43 (2%), 8/45 (18%; $P = 0.018$), 5/49 (10%), 7/48 (15%; $P = 0.042$) Carcinoma: 1/43 (2%), 0/45 (0%), 0/49 (0%), 0/48 (0%) Adenoma or carcinoma (combined): 2/43 (5%), 8/45 (18%), 5/49 (10%), 7/48 (15%) [There was no statistically significant positive trend in the incidence of pancreatic tumours, and no apparent progression to carcinoma] *Liver:* Hepatocellular adenoma: 2/44 (5%; P for trend = 0.016), 2/45 (4%), 3/49 (6%), 7/48 (15%) Hepatocellular carcinoma: 3/44 (7%); 2/45 (4%), 1/49 (2%), 2/48 (4%) Hepatocellular adenoma or carcinoma (combined): 5/44 (11%), 4/45 (9%), 4/49 (8%), 9/48 (19%) [There was no apparent progression to carcinoma] *Females* *Thyroid:* C-cell adenoma: 2/57 (4%; P for trend = 0.031), 2/60 (3%), 6/59 (10%), 6/55 (11%) C-cell carcinoma: 0/57, 0/60, 1/59 (2%), 0/55 C-cell adenoma or carcinoma (combined): 2/57 (4%), 2/60 (3%), 7/59 (12%), 6/55 (11%) [There was no apparent progression to carcinoma]

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Table 3.2 (continued)

Species, strain (sex) Duration Reference	Dosing regimen, Animals/group at start	For each target organ: incidence (%) and/or multiplicity of tumours	Significance	Comments
Rat Sprague-Dawley (M, F) Lifetime (up to 26 mo) EPA (1991a, b, c, d)	Diet containing glyphosate (purity, 98.7%) at concentrations of 0 ppm, 30 ppm (3 mg/kg bw per day), 100 ppm (10 mg/kg bw per day), 300 ppm (31 mg/kg bw per day), ad libitum, up to 26 mo 50 M and 50 F/group [age, NR]	*Males* *Pancreas (islet cell):* Adenoma: 0/50 (0%), 5/49* (10%), 2/50 (4%), 2/50 (4%) Carcinoma: 0/50 (0%), 0/49 (0%), 0/50 (0%), 1/50 (2%) Adenoma or carcinoma (combined): 0/50 (0%), 5/49 (10%), 2/50 (4%), 3/50 (6%) *Females* *Pancreas (islet cell):* Adenoma: 2/50 (4%), 1/50 (2%), 1/50 (2%), 0/50 (0%) Carcinoma: 0/50 (0%), 1/50 (2%), 1/50 (2%), 1/50 (2%) Adenoma or carcinoma (combined): 2/50 (10%), 2/50 (2%), 2/50 (74%), 1/50 (2%)	Adenoma, *[$P < 0.05$; Fisher exact test] NS	[There was no statistically significant positive trend in the incidence of pancreatic tumours, and no apparent progression to carcinoma]

bw, body weight; d, day; F, female; M, male; mo, month; NR, not reported; NS, not significant; wk, week; yr, year

males (P = 0.016) and of thyroid follicular cell adenoma in females (P = 0.031). [The Working Group noted that there was no apparent progression to carcinoma for either tumour type.]

The EPA (1991a, b, c, d) provided information on another long-term study in which groups of 50 male and 50 female Sprague-Dawley rats [age at start not reported] were given diets containing glyphosate (purity, 98.7%) at a concentration of 0, 30 (3 mg/kg bw per day), 100 (10 mg/kg bw per day), or 300 ppm (31 mg/kg bw per day), ad libitum, for life (up to 26 months). No information was provided on body weight or survival of the study animals. An increase in the incidence of pancreatic islet cell adenoma was reported in males at the lowest dose: controls, 0/50 (0%); lowest dose, 5/49 (10%) [$P < 0.05$; Fisher exact test]; intermediate dose, 2/50 (4%); highest dose, 2/50 (4%). [The Working Group noted that there was no statistically significant positive dose-related trend in the incidence of these tumours, and no apparent progression to carcinoma.]

3.2.3 Review articles

Greim *et al.* (2015) have published a review article containing information on nine long-term bioassay feeding studies in rats. Of these studies, two had been submitted for review to the EPA (1991a, b, c, d), two to the JMPR (JMPR, 2006), and one had been published in the openly available scientific literature (Chruscielska *et al.*, 2000); these studies are discussed earlier in Section 3.2. The review article reported on an additional four long-term bioassay studies in rats that had not been previously published, but had been submitted to various organizations for registration purposes. The review article provided a brief summary of each study and referred to an online data supplement containing the original data on tumour incidence from study reports. The four additional long-term bioassay studies in rats are summarized below. [The Working Group did not evaluate these studies, which are not included in Table 3.2 and Section 5.3, because the information provided in the review article and its supplement was insufficient (e.g. information lacking on statistical methods, choice of doses, body-weight gain, survival data, details on histopathological examination and/or stability of dosed feed mixture).]

In one study (identified as Study 4, 1996), groups of 50 male and 50 female Wistar rats [age at start not reported] were given diets containing glyphosate (purity, 96%) at a concentration of 0, 100, 1000, or 10 000 ppm, ad libitum, for 24 months. It was reported that hepatocellular adenomas and hepatocellular carcinomas were found at non-statistically significant incidences in both males and females. There was no significant increase in tumour incidence in the treated groups. [The Working Group was unable to evaluate this study because of the limited experimental data provided in the review article and supplemental information.]

In one study in Sprague-Dawley rats (identified as Study 5, 1997), groups of 50 male and 50 female rats [age at start not reported] were given diets containing glyphosate technical acid [purity not reported] at a concentration of 0, 3000, 15 000, or 25 000 ppm, ad libitum, for 24 months. There was no significant increase in tumour incidence in the treated groups. [The Working Group was unable to evaluate this study because of the limited experimental data provided in the review article and supplemental information.]

In a second study in Sprague Dawley rats (identified as Study 6, 1997b), groups of 50 males and 50 females [age at start not reported] were given diets containing glyphosate (purity, 94.6–97.6%) at a concentration of 0, 3000, 10 000, or 30 000 ppm, ad libitum, for 24 months. Non-significant increases in tumour incidences compared with controls were noted for skin keratoacanthoma in males at the highest dose, and for fibroadenoma of the mammary gland in females at the lowest and intermediate doses. [The Working Group was unable to evaluate this

study because of the limited experimental data provided in the review article and supplemental information.]

In another study in male and female Wistar rats (identified as Study 8, 2009b), groups of 51 male and 51 female rats [age at start not reported] were fed diets containing glyphosate (purity, 95.7%) at a concentration of 0, 1500, 5000, or 15 000 ppm, ad libitum, for 24 months. The highest dose was progressively increased to reach 24 000 ppm by week 40. A non-significant increase in tumour incidence was noted for adenocarcinoma of the mammary gland in females at the highest dose (6/51) compared with controls (2/51). [The Working Group was unable to evaluate this study because of the limited experimental data provided in the review article and supplemental information. The Working Group noted that tumours of the mammary gland had been observed in other studies in rats reviewed for the present *Monograph*.]

4. Mechanistic and Other Relevant Data

4.1 Toxicokinetic data

4.1.1 Introduction

The herbicidal activity of glyphosate is attributed to interference with the production of essential aromatic amino acids (EPA, 1993b). In plants, glyphosate competitively inhibits the activity of enolpyruvylshikimate phosphate synthase, an enzyme that is not present in mammalian cells. Glyphosate is degraded by soil microbes to aminomethylphosphonic acid (AMPA) (see Fig. 4.1), a metabolite that can accumulate in the environment. In mammals, glyphosate is not metabolized efficiently, and is mainly excreted unchanged into the urine; however, it has been suggested that glyphosate can undergo gut microbial metabolism in humans (Motojyuku *et al.*, 2008) and rodents (Brewster *et al.*, 1991).

4.1.2 Absorption

(a) Humans

Data on the absorption of glyphosate via intake of food and water in humans were not available to the Working Group. Inhalation of glyphosate is considered to be a minor route of exposure in humans, because glyphosate is usually formulated as an isopropylamine salt with a very low vapour pressure (Tomlin, 2000).

In the Farm Family Exposure Study, 60% of farmers had detectable levels of glyphosate in 24-hour composite urine samples taken on the day they had applied a glyphosate-based formulation (Acquavella *et al.*, 2004). Farmers who did not use rubber gloves had higher urinary concentrations of glyphosate than those who did use gloves [indicating that dermal absorption is a relevant route of exposure]. In a separate study, detectable levels of glyphosate were found in urine samples from farm families and non-farm families (Curwin *et al.*, 2007).

In accidental and deliberate intoxication cases involving ingestion of glyphosate-based formulations, glyphosate was readily detectable in the blood (Zouaoui *et al.*, 2013). After deliberate or accidental ingestion, one glyphosate-based formulation was found to be more lethal to humans than another (Sørensen & Gregersen, 1999). [Greater lethality was attributed to the presence of trimethylsulfonium counterion, which might facilitate greater absorption after oral exposure.]

Small amounts of glyphosate can be absorbed after dermal exposures in humans in vitro. For example, when an aqueous solution of 1% glyphosate was applied in an in-vitro human skin model, only 1.4% of the applied dose was absorbed through the skin. Glyphosate is typically formulated as an isopropylamine salt, and is dissolved in a water-based vehicle, while the

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stratum corneum is a lipid-rich tissue (Wester *et al.*, 1991). In-vitro studies using human skin showed that percutaneous absorption of a glyphosate-based formulation was no more than 2% of the administered dose over a concentration range of 0.5–154 μg/cm² and a topical volume range of 0.014–0.14 mL/cm². In addition, very little glyphosate (≤ 0.05% of the administered dose) was sequestered in the stratum corneum after dermal application (Wester *et al.*, 1991).

In the human Caco-2 cell line, an in-vitro model of intestinal enterocytes, glyphosate (> 10 mg/mL) was shown to significantly disrupt barrier properties, leading to an increase in paracellular permeability (transport of substances that pass through the intercellular space between the cells) (Vasiluk *et al.*, 2005).

(b) Experimental systems

Three studies have been conducted to investigate the absorption of a single oral dose of glyphosate in rats (Brewster *et al.*, 1991; Chan & Mahler, 1992; EPA, 1993b).

In male Sprague-Dawley rats given [^{14}C]-labelled glyphosate (10 mg/kg bw), the majority of the radiolabel was associated with the gastrointestinal contents and small intestinal tissue 2 hours after administration (Brewster *et al.*, 1991). Approximately 35–40% of the administered dose was found to be absorbed from the gastrointestinal tract. Urinary and faecal routes of elimination were equally important. [The Working Group concluded that glyphosate is incompletely absorbed from the gastrointestinal tract after oral exposure in rats.]

In a study by the United States National Toxicology Programme (NTP) in Fisher 344 rats, 30% of the administered oral dose (5.6 mg/kg bw) was absorbed, as determined by urinary excretion data (Chan & Mahler, 1992). This finding was in accordance with the previously described study of oral exposure in rats (Brewster *et al.*, 1991).

In a study reviewed by the EPA, Sprague-Dawley rats were given an oral dose of glyphosate (10 mg/kg bw); 30% and 36% of the administered dose was absorbed in males and females, respectively (EPA, 1993b). At a dose that was ~10-fold higher (1000 mg/kg bw), oral absorption of glyphosate by the rats was slightly reduced.

In a 14-day feeding study in Wistar rats given glyphosate at dietary concentrations of up to 100 ppm, only ~15% of the administered dose was found to be absorbed (JMPR, 2006). In New Zealand White rabbits or lactating goats given glyphosate as single oral doses (6–9 mg/kg bw), a large percentage of the administered dose was recovered in the faeces [suggesting very poor gastrointestinal absorption of glyphosate in these animal models] (JMPR, 2006).

In monkeys given glyphosate by dermal application, percutaneous absorption was estimated to be between 1% and 2% of the administered dose (Wester *et al.*, 1991). Most of the administered dose was removed by surface washes of the exposed skin.

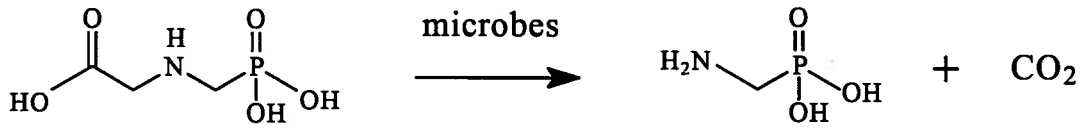
4.1.3 Distribution

(a) Humans

No data in humans on the distribution of glyphosate in systemic tissues other than blood were available to the Working Group. In cases of accidental or deliberate intoxication involving ingestion of glyphosate-based formulations, glyphosate was measured in blood. Mean blood concentrations of glyphosate were 61 mg/L and 4146 mg/L in mild-to-moderate cases of intoxication and in fatal cases, respectively (Zouaoui *et al.*, 2013).

One report, using optical spectroscopy and molecular modelling, indicated that glyphosate could bind to human serum albumin, mainly by hydrogen bonding; however, the fraction of glyphosate that might bind to serum proteins in blood was not actually measured (Yue *et al.*, 2008).

Fig. 4.1 Microbial metabolism of glyphosate to AMPA



Glyphosate is degraded to AMPA by microbial metabolism
Compiled by the Working Group

(b) Experimental systems

In Sprague-Dawley rats given a single oral dose of glyphosate (100 mg/kg bw), glyphosate concentrations in plasma reached peak levels, then declined slowly from day 1 to day 5 (Bernal *et al.*, 2010). The plasma data appeared to fit a one-compartment model with an elimination rate constant of k_{el} = 0.021 hour^{-1}. [The Working Group estimated the elimination half-life of glyphosate to be 33 hours.] Tissue levels of glyphosate were not determined in this study. In a study by Brewster *et al.* (1991), the tissue levels of glyphosate at 2, 6.3, 28, 96, and 168 hours in Sprague-Dawley rats given a single oral dose (10 mg/kg bw) declined rapidly. Tissues with the greatest amounts of detectable radiolabel (> 1% of the administered dose) were the small intestine, colon, kidney, and bone. Peak levels were reached in small intestine tissue and blood by 2 hours, while peak levels in other tissues occurred at 6.3 hours after dosing. After 7 days, the total body burden of [^{14}C]-labelled residues was ~1% of the administered dose, and was primarily associated with the bone (~1 ppm). In every tissue examined after administration of [^{14}C]-labelled glyphosate, essentially 100% of the radiolabel that was present in the tissue was unmetabolized parent glyphosate. Thus, essentially 100% of the body burden was parent compound, with no significant persistence of glyphosate after 7 days (Brewster *et al.*, 1991). In a 14-day feeding study in Wistar rats given diets containing glyphosate at 100 ppm, glyphosate reached steady-state levels in the blood by day 6 (JMPR, 2006). The tissue concentrations of glyphosate had the following rank order: kidneys > spleen > fat > liver. Tissue levels declined rapidly after cessation of exposure to glyphosate. A second study in rats given glyphosate (10 mg/kg bw per day, 14 days) followed by a single oral dose of [^{14}C]-glyphosate (at 10 mg/kg bw) showed that repeated dosing did not alter the tissue distribution of glyphosate (JMPR, 2006).

In rhesus monkeys, tissues harvested 7 days after dermal exposures to [^{14}C]-labelled glyphosate did not contain radiolabel at detectable levels (Wester *et al.*, 1991).

4.1.4 Metabolism and modulation of metabolic enzymes

(a) Metabolism

Glyphosate is degraded in the environment by soil microbes, primarily to AMPA and carbon dioxide (Fig. 4.1; Jacob *et al.*, 1988). A minor pathway for the degradation of glyphosate in bacteria (*Pseudomonas sp.* strain LBr) is via conversion to glycine (Jacob *et al.*, 1988). In a case of deliberate poisoning with a glyphosate-based formulation, small amounts of AMPA (15.1 µg/mL) were detectable in the blood (Motojyuku *et al.*, 2008) [suggesting that this pathway might also operate in humans]. In rats given a single high oral dose of glyphosate (100 mg/kg bw), small amounts of AMPA were detected in the plasma (Bernal *et al.*, 2010). In

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male Sprague-Dawley rats given an oral dose of glyphosate (10 mg/kg bw), a very small amount of AMPA (< 0.04% of the administered dose) was detected in the colon 2 hours after dosing; this was attributed to intestinal microbial metabolism (Brewster *et al.*, 1991).

(b) Modulation of metabolic enzymes

(i) Humans

In human hepatic cell lines, treatment with one of four glyphosate-based formulations produced by the same company was shown to enhance CYP3A4 and CYP1A2 levels, while glutathione transferase levels were reduced (Gasnier *et al.*, 2010). [The Working Group noted that it was not clear whether the effects were caused by glyphosate alone or by the adjuvants contained in the formulation.]

(ii) Experimental systems

Exposure of Wistar rats to a glyphosate-based formulation significantly altered some hepatic xenobiotic enzyme activities (Larsen *et al.*, 2014). Liver microsomes obtained from male and female rats treated with the formulation exhibited ~50% reductions in cytochrome P450 (CYP450) content compared with control (untreated) rats. However, opposing effects were observed when assessing 7-ethoxycoumarin *O*-deethylase activity (7-ECOD, a non-specific CYP450 substrate). Female rats treated with the glyphosate-based formulation exhibited a 57% increase in hepatic microsomal 7-ECOD activity compared with controls, while male rats treated with the formulation exhibited a 58% decrease in this activity (Larsen *et al.*, 2014). [The Working Group noted that it was not clear whether the effects were caused by glyphosate alone or by adjuvants contained in the formulation.]

4.1.5 Excretion

(a) Humans

Excretion of glyphosate in humans was documented in several biomonitoring studies. For example, as part of the Farm Family Exposure Study, urinary concentrations of glyphosate were evaluated immediately before, during, and after glyphosate application in 48 farmers and their spouses and children (Acquavella *et al.*, 2004). Dermal contact with glyphosate during mixing, loading, and application was considered to be the main route of exposure in the study. On the day the herbicide was applied, 60% of the farmers had detectable levels of glyphosate in 24-hour composite urine samples, as did 4% of their spouses and 12% of children. For farmers, the geometric mean concentration was 3 µg/L, the maximum value was 233 µg/L, and the highest estimated systemic dose was 0.004 mg/kg bw (Acquavella *et al.*, 2004). In a separate study, detectable levels of glyphosate were excreted in the urine of members of farm families and of non-farm families, with geometric means ranging from 1.2 to 2.7 µg/L (Curwin *et al.*, 2007).

In a study of a rural population living near areas sprayed for drug eradication in Colombia (see Section 1.4.1, Table 1.5), mean urinary glyphosate concentrations were 7.6 µg/L (range, undetectable to 130 µg/L) (Varona *et al.*, 2009). AMPA was detected in 4% of urine samples (arithmetic mean, 1.6 µg/L; range, undetectable to 56 µg/L).

(b) Experimental systems

In an NTP study in Fisher 344 rats given a single oral dose of [^{14}C]-labelled glyphosate (5.6 or 56 mg/kg bw), it was shown that > 90% of the radiolabel was eliminated in the urine and faeces within 72 hours (Chan & Mahler, 1992). In Sprague-Dawley rats given [^{14}C]-labelled glyphosate at an oral dose of 10 or 1000 mg/kg bw, ~60–70% of the administered dose was excreted in the faeces, and the remainder in the urine (EPA,

1993b). By either route, most (98%) of the administered dose was excreted as unchanged parent compound. AMPA was the only metabolite found in the urine (0.2–0.3% of the administered dose) and faeces (0.2–0.4% of the administered dose). [The large amount of glyphosate excreted in the faeces is consistent with its poor oral absorption.] Less than 0.3% of the administered dose was expired as carbon dioxide.

In rhesus monkeys given glyphosate as an intravenous dose (9 or 93 µg), > 95% of the administered dose was excreted in the urine (Wester *et al.*, 1991). Nearly all the administered dose was eliminated within 24 hours. In contrast, in rhesus monkeys given glyphosate by dermal application (5400 µg/20 cm²), only 2.2% of the administered dose was excreted in the urine within 7 days (Wester *et al.*, 1991).

Overall, systemically absorbed glyphosate is not metabolized efficiently, and is mainly excreted unchanged into the urine.

4.2 Mechanisms of carcinogenesis

4.2.1 Genetic and related effects

Glyphosate has been studied for genotoxic potential in a wide variety of assays. Studies carried out in exposed humans, in human cells in vitro, in other mammals in vivo and in vitro, and in non-mammalian systems in vivo and in vitro, respectively, are summarized in Table 4.1, Table 4.2, Table 4.3, Table 4.4, and Table 4.5. [A review article by Kier & Kirkland (2013) summarized the results of published articles and unpublished reports of studies pertaining to the genotoxicity of glyphosate and glyphosate formulations. A supplement to this report contained information on 66 unpublished regulatory studies. The conclusions and data tables for each individual study were included in the supplement; however, the primary study reports from which these data were extracted were not available to the Working Group. The information provided in the supplement was insufficient regarding topics such as details of statistical methods, choice of the highest dose tested, and verification of the target tissue exposure. The Working Group determined that the information in the supplement to Kier & Kirkland (2013) did not meet the criteria for data inclusion as laid out in the Preamble to the *IARC Monographs*, being neither "reports that have been published or accepted for publication in the openly available scientific literature" nor "data from governmental reports that are publicly available" (IARC, 2006). The review article and supplement were not considered further in the evaluation.]

(a) Humans

(i) Studies in exposed humans

See Table 4.1

In exposed individuals (n = 24) living in northern Ecuador in areas sprayed with a glyphosate-based formulation, a statistically significant increase in DNA damage (DNA strand breaks) was observed in blood cells collected 2 weeks to 2 months after spraying (Paz-y-Miño *et al.*, 2007). The same authors studied blood cells from individuals (n = 92) in 10 communities in Ecuador's northern border, who were sampled 2 years after the last aerial spraying with a herbicide mix containing glyphosate, and showed that their karyotypes were normal compared with those of a control group (Paz-y-Miño *et al.*, 2011).

Bolognesi *et al.* (2009) studied community residents (137 women of reproductive age and their 137 spouses) from five regions in Colombia. In three regions with exposures to glyphosate-based formulations from aerial spraying, blood samples were taken from the same individuals at three time-points (before spraying (baseline), 5 days after spraying and 4 months after spraying) to determine the frequency of micronucleus formation in lymphocytes. The baseline frequency of binucleated cells with micronuclei was significantly higher in subjects

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from the three regions where there had been aerial spraying with glyphosate-formulations and in a fourth region with pesticide exposure (but not through aerial spraying), compared with a reference region (without use of pesticide). The frequency of micronucleus formation in peripheral blood lymphocytes was significantly increased, compared with baseline levels in the same individuals, after aerial spraying with glyphosate-based formulations in each of the three regions (see Table 4.1; Bolognesi *et al.*, 2009). Immediately after spraying, subjects who reported direct contact with the glyphosate-based spray showed a higher frequency of binucleated cells with micronuclei. However, the increase in frequency of micronucleus formation observed immediately after spraying was not consistent with the rates of application used in the regions, and there was no association between self-reported direct contact with pesticide sprays and frequency of binucleated cells with micronuclei. In subjects from one but not other regions, the frequency of binucleated cells with micronuclei was significantly decreased 4 months after spraying, compared with immediately after spraying.

(ii) Human cells in vitro

See Table 4.2

Glyphosate induced DNA strand breaks (as measured by the comet assay) in liver Hep-2 cells (Mañas *et al.*, 2009a), lymphocytes (Mladinic *et al.*, 2009b; Alvarez-Moya *et al.*, 2014), GM38 fibroblasts, the HT1080 fibrosarcoma cell line (Monroy *et al.*, 2005), and the TR146 buccal carcinoma line (Koller *et al.*, 2012). DNA strand breaks were induced by AMPA in Hep-2 cells (Mañas *et al.*, 2009b), and by a glyphosate-based formulation in the TR146 buccal carcinoma cell line (Koller *et al.*, 2012).

In human lymphocytes, AMPA (Mañas *et al.*, 2009b), but not glyphosate (Mañas *et al.*, 2009a), produced chromosomal aberrations. Glyphosate did not induce a concentration-related increase in micronucleus formation in human lymphocytes at levels estimated to correspond to occupational and residential exposure (Mladinic *et al.*, 2009a). Sister-chromatid exchange was induced by glyphosate (Bolognesi *et al.*, 1997), and by a glyphosate-based formulation (Vigfusson & Vyse, 1980; Bolognesi *et al.*, 1997) in human lymphocytes exposed in vitro.

(b) Experimental systems

(i) Non-human mammals in vivo

See Table 4.3

The ability of glyphosate or a glyphosate-based formulation to induce DNA adducts was studied in mice given a single intraperitoneal dose. Glyphosate induced DNA adducts (8-hydroxy deoxyguanosine) in the liver, but not in the kidney, while a glyphosate-based formulation caused a slight increase in DNA adducts in the kidney, but not in the liver (Bolognesi *et al.*, 1997). Peluso *et al.* (1998) showed that a glyphosate-based formulation (glyphosate, 30.4%), but not glyphosate alone, caused DNA adducts (as detected by ^{32}P-DNA post-labelling) in mouse liver and kidney. Glyphosate and a glyphosate-based formulation produced DNA strand breaks in the liver and kidney after a single intraperitoneal dose (Bolognesi *et al.*, 1997).

In mice given a single dose of glyphosate by gavage, no genotoxic effect was observed by the dominant lethal test (EPA, 1980a).

After a single intraperitoneal dose, no chromosomal aberrations were observed in the bone marrow of rats treated with glyphosate (Li & Long 1988), while chromosomal aberrations were increased in the bone marrow of mice given a glyphosate-based formulation (glyphosate isopropylamine salt, ~41%) (Prasad *et al.*, 2009). A single oral dose of a glyphosate-based formulation did not cause chromosomal aberrations in mice (Dimitrov *et al.*, 2006).

In mice treated by intraperitoneal injection, a single dose of glyphosate did not cause

Table 4.1 Genetic and related effects of glyphosate in exposed humans

Tissue	Cell type (if specified)	End-point	Test	Description of exposure and controls	Response[a]/ significance	Comments	Reference
Blood	NR	DNA damage	DNA strand breaks, comet assay	24 exposed individuals in northern Ecuador; areas sprayed with glyphosate-based formulation (sampling 2 weeks to 2 months after spraying); control group was 21 non-exposed individuals	+ $P < 0.001$		Paz-y-Miño *et al.* (2007)
Blood	NR	Chromosomal damage	Chromosomal aberrations	92 individuals in 10 communities, northern border of Ecuador; sampling 2 years after last aerial spraying with herbicide mix containing glyphosate); control group was 90 healthy individuals from several provinces without background of smoking or exposure to genotoxic substances (hydrocarbons, X-rays, or pesticides)	–	182 karyotypes were considered normal [Smoking status, NR]	Paz-y-Miño *et al.* (2011)
Blood	Lymphocytes	Chromosomal damage	Micronucleus formation	55 community residents, Nariño, Colombia; area with aerial glyphosate-based formulation spraying for coca and poppy eradication (glyphosate was tank-mixed with an adjuvant)	+ [$P < 0.001$]	P values for after spraying vs before spraying in the same individuals	Bolognesi *et al.* (2009)
Blood	Lymphocytes	Chromosomal damage	Micronucleus formation	53 community residents, Putumayo, Colombia; area with aerial glyphosate-based formulation spraying for coca and poppy eradication (glyphosate was tank-mixed with an adjuvant)	+ [$P = 0.01$]	P values for after spraying vs before spraying in the same individuals	Bolognesi *et al.* (2009)
Blood	Lymphocytes	Chromosomal damage	Micronucleus formation	27 community residents, Valle del Cauca, Colombia; area where glyphosate-based formulation was applied through aerial spraying for sugar-cane maturation (glyphosate was applied without adjuvant)	+ [$P < 0.001$]	P values for after spraying vs before spraying in the same individuals	Bolognesi *et al.* (2009)

[a] +, positive; –, negative
NR, not reported; vs, versus

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micronucleus formation in the bone marrow (Rank *et al.*, 1993), although two daily doses did (Bolognesi *et al.*, 1997; Mañas *et al.*, 2009a). AMPA, the main metabolite of glyphosate, also produced micronucleus formation after two daily intraperitoneal doses (Mañas *et al.*, 2009b). Conflicting results for micronucleus induction were obtained in mice exposed intraperitoneally to a glyphosate-based formulation. A single dose of the formulation at up to 200 mg/kg bw did not induce micronucleus formation in the bone marrow in one study (Rank *et al.* 1993), while it did increase micronucleus formation at 25 mg/kg bw in another study (Prasad *et al.*, 2009). After two daily intraperitoneal doses, a glyphosate-based formulation did not induce micronucleus formation at up to 200 mg/kg bw according to Grisolia (2002), while Bolognesi *et al.* (1997) showed that the formulation did induce micronucleus formation at 450 mg/kg bw. In mice given a single oral dose of a glyphosate-based formulation at 1080 mg/kg bw, no induction of micronuclei was observed (Dimitrov *et al.*, 2006).

(ii) Non-human mammalian cells in vitro

See Table 4.4

Glyphosate did not induce unscheduled DNA synthesis in rat primary hepatocytes, or *Hprt* mutation (with or without metabolic activation) in Chinese hamster ovary cells (Li & Long, 1988).

In bovine lymphocytes, chromosomal aberrations were induced by glyphosate in one study (Lioi *et al.*, 1998), but not by a glyphosate formulation in another study (Siviková & Dianovský, 2006). Roustan *et al.* (2014) demonstrated, in the CHO-K1 ovary cell line, that glyphosate induced micronucleus formation only in the presence of metabolic activation, while AMPA induced micronucleus formation both with and without metabolic activation. Sister-chromatid exchange was observed in bovine lymphocytes exposed to glyphosate (Lioi *et al.*, 1998) or a glyphosate formulation (in the absence but not the presence of metabolic activation) (Siviková & Dianovský, 2006).

(iii) Non-mammalian systems in vivo

See Table 4.5

Fish and other species

In fish, glyphosate produced DNA strand breaks in the comet assay in sábalo (Moreno *et al.*, 2014), European eel (Guilherme *et al.*, 2012b), zebrafish (Lopes *et al.*, 2014), and Nile tilapia (Alvarez-Moya *et al.*, 2014). AMPA also induced DNA strand breaks in the comet assay in European eel (Guilherme *et al.*, 2014b). A glyphosate-based formulation produced DNA strand breaks in numerous fish species, such as European eel (Guilherme *et al.*, 2010, 2012b, 2014a; Marques *et al.*, 2014, 2015), sábalo (Cavalcante *et al.*, 2008; Moreno *et al.*, 2014), guppy (De Souza Filho *et al.*, 2013), bloch (Nwani *et al.*, 2013), neotropical fish *Corydoras paleatus* (de Castilhos Ghisi & Cestari, 2013), carp (Gholami-Seyedkolaei *et al.*, 2013), and goldfish (Cavaş & Könen, 2007).

AMPA, the main metabolite of glyphosate, induced erythrocytic nuclear abnormalities (kidney-shaped and lobed nuclei, binucleate or segmented nuclei and micronuclei) in European eel (Guilherme *et al.*, 2014b). Micronucleus formation was induced by different glyphosate-based formulations in various fish (Grisolia, 2002; Cavaş & Könen, 2007; De Souza Filho *et al.*, 2013; Vera-Candioti *et al.*, 2013).

Glyphosate-based formulations induced DNA strand breaks in other species, including caiman (Poletta *et al.*, 2009), frog (Meza-Joya *et al.*, 2013), tadpoles (Clements *et al.*, 1997), and snail (Mohamed, 2011), but not in oyster (Akcha *et al.*, 2012), clam (dos Santos & Martinez, 2014), and mussel glochidia (Conners & Black, 2004). In earthworms, one glyphosate-based formulation induced DNA strand breaks while two others did not (Piola *et al.*, 2013; Muangphra *et al.*, 2014), highlighting the potential importance of components other than the active ingredient in the formulation.

Table 4.2 Genetic and related effects of glyphosate, AMPA, and glyphosate-based formulations in human cells in vitro

Tissue, cell line	End-point	Test	Results[a]		Dose (LED or HID)	Comments	Reference
			Without metabolic activation	With metabolic activation			
Glyphosate							
Liver Hep-2	DNA damage	DNA strand breaks, comet assay	+	NT	3 mM [507.2 µg/mL]	$P < 0.01$; dose–response relationship ($r \geq 0.90$; $P < 0.05$)	Mañas et al. (2009a)
Lymphocytes	DNA damage	DNA strand breaks, standard and hOGG1 modified comet assay	+	+	3.5 µg/mL	With the hOGG1 modified comet assay, + S9, the increase was significant ($P < 0.01$) only at the highest dose tested (580 µg/mL)	Mladinic *et al.* (2009b)
Lymphocytes	DNA damage	DNA strand breaks, comet assay	+	NT	0.0007 mM [0.12 µg/mL]	$P \leq 0.01$	Alvarez-Moya *et al.* (2014)
Fibroblast GM 38	DNA damage	DNA strand breaks, comet assay	+	NT	4 mM [676 µg/mL]	$P < 0.001$	Monroy *et al.* (2005)
Fibroblast GM 5757	DNA damage	DNA strand breaks, comet assay	(+)	NT	75 mM [12 680 µg/mL]	Glyphosate (ineffective alone, data NR) increased strand breaks induced by H_2O_2 (40 or 50 µM) ($P < 0.004$ vs H_2O_2 alone)	Lueken *et al.* (2004)
Fibrosarcoma HT1080	DNA damage	DNA strand breaks, comet assay	+	NT	4.75 mM [803 µg/mL]	$P < 0.001$	Monroy *et al.* (2005)
Buccal carcinoma TR146	DNA damage	DNA strand breaks, SCGE assay	+	NT	20 µg/mL	Dose-dependent increase ($P \leq 0.05$)	Koller *et al.* (2012)
Lymphocytes	Chromosomal damage	Chromosomal aberrations	–	NT	6 mM [1015 µg/mL]		Mañas *et al.* (2009a)
Lymphocytes	Chromosomal damage	Micronucleus formation	–	(+)	580 µg/mL	$P < 0.01$ at the highest exposure + S9 No concentration-related increase in micronuclei containing the centromere signal (C+)	Mladinic *et al.* (2009a)

Table 4.2 (continued)

Tissue, cell line	End-point	Test	Results[a]		Dose (LED or HID)	Comments	Reference
			Without metabolic activation	With metabolic activation			
Lymphocytes	Chromosomal damage	Sister-chromatid exchange	+	NT	1000 µg/mL	$P < 0.05$	Bolognesi *et al.* (1997)
AMPA							
Liver Hep-2	DNA damage	DNA strand breaks, comet assay	+	NT	4.5 mM [500 µg/mL]	$P < 0.05$ at 4.5 mM; $P < 0.01$ at up to 7.5 mM Dose–response relationship ($r \geq 0.90$; $P < 0.05$)	Mañas *et al.* (2009b)
Lymphocytes	Chromosomal damage	Chromosomal aberrations	+	NT	1.8 mM [200 µg/mL]	$P < 0.05$	Mañas *et al.* (2009b)
Glyphosate-based formulations							
Liver HepG2	DNA damage	DNA strand breaks, comet assay	(+)	NT	5 ppm	Glyphosate, 400 g/L Dose-dependent increase; greatest increase at 10 ppm Statistical analysis, NR	Gasnier *et al.* (2009)
Buccal carcinoma TR146	DNA damage	DNA strand breaks, SCGE assay	+	NT	20 µg/mL	Glyphosate acid, 450g/L Dose-dependent increase ($P \leq 0.05$)	Koller *et al.* (2012)
Lymphocytes	Chromosomal damage	Sister-chromatid exchange	+	NT	250 µg/mL	$P < 0.001$ No growth at 25 mg/mL	Vigfusson & Vyse (1980)
Lymphocytes	Chromosomal damage	Sister-chromatid exchange	+	NT	100 µg/mL	Glyphosate, 30.4% $P < 0.05$	Bolognesi *et al.* (1997)

[a] +, positive; -, negative; (+) or (-) positive/negative in a study with limited quality

AMPA, aminomethyl phosphonic acid; HID, highest ineffective dose; hOGG1, human 8-hydroxyguanosine DNA-glycosylase; LED, lowest effective dose; NR, not reported; NT, not tested; S9, 9000 × *g* supernatant; SCGE, single cell gel electrophoresis; vs, versus

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Micronucleus formation was induced by a glyphosate-based formulation (glyphosate, 36%) in earthworms (Muangphra *et al.*, 2014), and by a different glyphosate-based formulation in caiman (Poletta *et al.*, 2009, 2011), and frog (Yadav *et al.*, 2013).

Insects

In standard *Drosophila melanogaster*, glyphosate induced mutation in the test for somatic mutation and recombination, but not in a cross of flies characterized by an increased capacity for CYP450-dependent bioactivation (Kaya *et al.*, 2000). A glyphosate-based formulation also caused sex-linked recessive lethal mutations in *Drosophila* (Kale *et al.*, 1995).

Plants

In plants, glyphosate produced DNA damage in *Tradescantia* in the comet assay (Alvarez-Moya *et al.*, 2011). Chromosomal aberration was induced after exposure to glyphosate in fenugreek (Siddiqui *et al.*, 2012), and in onion in one study (Frescura *et al.*, 2013), but not in another (Rank *et al.*, 1993). A glyphosate-based formulation also induced chromosomal aberration in barley roots (Truta *et al.*, 2011) and onion (Rank *et al.*, 1993), but not in *Crepis capillaris* (hawksbeard) (Dimitrov *et al.*, 2006). Micronucleus formation was not induced by glyphosate in *Vicia faba* bean (De Marco *et al.*, 1992) or by a glyphosate-based formulation in *Crepis capillaris* (Dimitrov *et al.*, 2006).

(iv) Non-mammalian systems in vitro

See Table 4.6

Glyphosate induced DNA strand breaks in erythrocytes of tilapia fish, as demonstrated by comet assay (Alvarez-Moya *et al.*, 2014).

Glyphosate did not induce mutation in *Bacillus subtillis*, *Salmonella typhimurium* strains TA1535, TA1537, TA1538, TA98, and TA100, or in *Escherichia coli* WP2, with or without metabolic activation (Li & Long, 1988). However, Rank *et al.* (1993) demonstrated that a glyphosate-based formulation was mutagenic in *S. typhimurium* TA98 in the absence of metabolic activation, and in *S. typhimurium* TA100 in the presence of metabolic activation.

4.2.2 Receptor-mediated mechanisms

(a) Sex-hormone pathway disruption

(i) Humans

Studies in exposed humans

No data were available to the Working Group.

Human cells in vitro

In hormone-dependent T47D breast cancer cells, the proliferative effects of glyphosate (10^{-6} to 1 μM) (see Section 4.2.4) and those of 17β-estradiol (the positive control) were mitigated by the estrogen receptor antagonist, ICI 182780; the proliferative effect of glyphosate was completely abrogated by the antagonist at a concentration of 10 nM (Thongprakaisang *et al.*, 2013). Glyphosate also induced activation of the estrogen response element (ERE) in T47D breast cancer cells that were stably transfected with a triplet ERE-promoter-luciferase reporter gene construct. Incubation with ICI 182780 at 10 nM eliminated the response. When the transfected cells were incubated with both 17β-estradiol and glyphosate, the effect of 17β-estradiol was reduced and glyphosate behaved as an estrogen antagonist. After 6 hours of incubation, glyphosate increased levels of estrogen receptors ERα and ERβ in a dose-dependent manner in T47D cells; after 24 hours, only ERβ levels were increased and only at the highest dose of glyphosate. [These findings suggested that the proliferative effects of glyphosate on T47D cells are mediated by ER.]

In human hepatocarcinoma HepG2 cells, four glyphosate-based formulations produced by the same company had a marked effect on the activity and transcription of aromatase, while glyphosate alone differed from controls, but not significantly so (Gasnier *et al.*, 2009).

Table 4.3 Genetic and related effects of glyphosate, AMPA, and glyphosate-based formulations in non-human mammals in vivo

Species, strain (sex)	Tissue	End-point	Test	Results	Dose (LED or HID)	Route, duration, dosing regimen	Comments	Reference
Glyphosate								
Mouse, Swiss CD1 (M)	Liver	DNA damage	DNA adducts, 8-OHdG by LC/UV	+	300 mg/kg bw	i.p.; 1×; sampled after 8 and 24 h	Single dose tested only $P < 0.05$ after 24 h	Bolognesi *et al.* (1997)
Mouse, Swiss CD1 (M)	Kidney	DNA damage	DNA adducts, 8-OHdG by LC/UV	–	300 mg/kg bw	i.p.; 1×; sampled after 8 and 24 h	Single dose tested only	Bolognesi *et al.* (1997)
Mouse, Swiss CD1 (M, F)	Kidney	DNA damage	DNA adducts, ^{32}P-DNA post labelling	–	270 mg/kg bw	i.p.; 1 ×; sampled after 24 h	Glyphosate isopropylammonium salt	Peluso *et al.* (1998)
Mouse, Swiss CD1 (M, F)	Liver	DNA damage	DNA adducts, ^{32}P-DNA post labelling	–	270 mg/kg bw	i.p.; 1 ×; sampled after 24 h	Glyphosate isopropylammonium salt	Peluso *et al.* (1998)
Mouse, Swiss CD1 (M)	Liver	DNA damage	DNA strand breaks, alkaline elution assay	+	300 mg/kg bw	i.p.; 1 ×; sampled after 4 and 24 h	Single dose tested only $P < 0.05$ after 4 h	Bolognesi *et al.* (1997)
Mouse, Swiss CD1 (M)	Kidney	DNA damage	DNA strand breaks, alkaline elution assay	+	300 mg/kg bw	i.p.; 1 ×; sampled after 4 and 24 h	Single dose tested only $P < 0.05$ after 4 h	Bolognesi *et al.* (1997)
Mouse, CD-1 (M)	Uterus after mating	Mutation	Dominant lethal test	–	2000 mg/kg bw	Oral gavage; 1 ×	Proportion of early resorptions evaluated after mating of non-treated females with glyphosate-treated male mice	EPA (1980)
Rat, Sprague-Dawley (M, F)	Bone marrow	Chromosomal damage	Chromosomal aberrations	–	1000 mg/kg bw	i.p.; 1 ×; sampled after 6, 12 and 24 h	Single dose tested only	Li & Long (1988)
Mouse, NMRI-bom (M, F)	Bone marrow (PCE)	Chromosomal damage	Micronucleus formation	–	200 mg/kg bw	i.p.; 1 ×; sampled after 24 and 48 h	Glyphosate isopropylamine salt	Rank *et al.* (1993)
Mouse, Swiss CD1 (M)	Bone marrow (PCE)	Chromosomal damage	Micronucleus formation	+	300 mg/kg bw	i.p.; 2 × 150 mg/kg bw with 24 h interval; sampled 6 or 24 h after the last injection	Single dose tested only $P < 0.05$ after 24 h	Bolognesi *et al.* (1997)

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Table 4.3 (continued)

Species, strain (sex)	Tissue	End-point	Test	Results	Dose (LED or HID)	Route, duration, dosing regimen	Comments	Reference
Mouse, Balb C (M, F)	Bone marrow (PCE)	Chromosomal damage	Micronucleus formation	+	400 mg/kg bw	i.p.; one injection per 24 h, 2 × 200, sampled 24 h after the last injection	$P < 0.01$ at the highest dose (400 mg/kg bw)	Mañas *et al.* (2009a)
AMPA								
Mouse, Balb C (M, F)	Bone marrow (PCE)	Chromosomal damage	Micronucleus formation	+	200 mg/kg bw	i.p.; one injection per 24 h, 2 × 100, sampled 24 h after the last injection	$P < 0.01$ at the lowest dose (200 mg/kg bw)	Mañas *et al.* (2009b)
Glyphosate-based formulations								
Mouse, Swiss CD1 (M)	Liver	DNA damage	DNA adducts, 8-OHdG by LC/UV	–	~300 mg/kg bw	i.p.; 1 ×, sampled after 8 and 24 h	Glyphosate, 30.4% Single dose tested only	Bolognesi *et al.* (1997)
Mouse, Swiss CD1 (M)	Kidney	DNA damage	DNA adducts, 8-OHdG by LC/UV	+	~300 mg/kg bw	i.p.; 1 ×, sampled after 8 and 24 h	Glyphosate, 30.4% Single dose tested only $P < 0.05$	Bolognesi *et al.* (1997)
Mouse, Swiss CD1 (M, F)	Kidney	DNA damage	DNA adducts, ^{32}P-DNA post labelling	+	400 mg/kg bw	i.p.; 1 ×; sampled after 24 h	Glyphosate isopropylammonium salt, 30.4%	Peluso *et al.* (1998)
Mouse, Swiss CD1 (M, F)	Liver	DNA damage	DNA adducts, ^{32}P-DNA post labelling	+	400 mg/kg bw	i.p.; 1 ×; sampled after 24 h	Glyphosate isopropylammonium salt, 30.4%	Peluso *et al.* (1998)
Mouse, Swiss CD1 (M)	Liver	DNA damage	DNA strand breaks, alkaline elution assay	+	~300 mg/kg bw	i.p.; 1 ×; sampled after 4 and 24 h	Glyphosate, 30.4% Single dose tested only $P < 0.05$ only after 4 h	Bolognesi *et al.* (1997)
Mouse, Swiss CD1 (M)	Kidney	DNA damage	DNA strand breaks, alkaline elution assay	+	~300 mg/kg bw	i.p.; 1 ×; sampled after 4 and 24 h	Glyphosate, 30.4% Single dose tested only $P < 0.05$ only after 4 h	Bolognesi *et al.* (1997)
Mouse, C57BL (M)	Bone marrow (PCE)	Chromosomal damage	Chromosomal aberrations	–	1080 mg/kg bw	p.o. in distilled water; 1 ×; sampled after 6, 24, 48, 72, 96 and 120 h	Single dose tested only	Dimitrov *et al.* (2006)

Table 4.3 (continued)

Species, strain (sex)	Tissue	End-point	Test	Results	Dose (LED or HID)	Route, duration, dosing regimen	Comments	Reference
Mouse, Swiss albino (M)	Bone marrow	Chromosomal damage	Chromosomal aberrations	+	25 mg/kg bw	i.p.; 1 ×; sampled after 24, 48 and 72 h	Glyphosate isopropylamine salt, > 41% The percentage of aberrant cells was increased vs control in a dose- and time-dependent manner ($P < 0.05$)	Prasad *et al.* (2009)
Mouse, NMRI-bom (M, F)	Bone marrow (PCE)	Chromosomal damage	Micronucleus formation	–	200 mg/kg bw	i.p.; 1 ×; sampled after 24 h	Glyphosate isopropylammonium salt, 480 g/L The percentage of PCE decreased	Rank *et al.* (1993)
Mouse, Swiss (M, F)	Bone marrow (PCE)	Chromosomal damage	Micronucleus formation	–	200 mg/kg bw	i.p.; 2 × within 24 h interval and sampled 24 h after the last injection	Glyphosate isopropylammonium salt, 480 g/L	Grisolia (2002)
Mouse, Swiss albino (M)	Bone marrow (PCE)	Chromosomal damage	Micronucleus formation	+	25 mg/kg bw	i.p.; 1 × ; sampled after 24, 48 and 72 h	Glyphosate isopropylamine salt, > 41% Significant induction of micronuclei vs control at both doses and all times ($P < 0.05$)	Prasad *et al.* (2009)
Mouse, Swiss CD1 (M)	Bone marrow (PCE)	Chromosomal damage	Micronucleus formation	+	450 mg/kg bw	i.p.; 2 × 225 mg/kg with 24 h interval; sampled 6 or 24 h after the last injection	Glyphosate, 30.4% Single dose tested only $P < 0.05$ after 6 h and 24 h	Bolognesi *et al.* (1997)
Mouse, C57BL (M)	Bone marrow	Chromosomal damage	Micronucleus formation	–	1080 mg/kg bw	p.o. in distilled water; 1 × ; sampled after 24, 48, 72, 96 and 120 h	Single dose tested only	Dimitrov *et al.* (2006)

[a] +, positive; -, negative; (+) or (-) positive/negative in a study with limited quality

bw, body weight; F, female; h, hour; HID, highest effective dose; i.p., intraperitoneal; LC, liquid chromatography; LED, lowest effective dose; M, male; PCE, polychromatic erythrocytes; p.o., oral; 8-OHdG, 8-hydroxydeoxyguanosine; UV, ultraviolet

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Table 4.4 Genetic and related effects of glyphosate, AMPA, and glyphosate-based formulations in non-human mammalian cells in vitro

Species	Tissue, cell line	End-point	Test	Results[a]		Dose (LEC or HIC)	Comments	Reference
				Without metabolic activation	With metabolic activation			
Glyphosate								
Rat, Fisher F334	Hepatocytes	DNA damage	Unscheduled DNA synthesis	–	NT	125 µg/mL		Li & Long (1988)
Hamster, Chinese	CHO-K_1BH_4 ovary, cell line	Mutation	*Hprt* mutation	–	–	22 500 µg/mL		Li & Long (1988)
Bovine	Lymphocytes	Chromosomal damage	Chromosomal aberrations	+	NT	17 µM [3 µg/mL]	$P < 0.05$	Lioi *et al.* (1998)
Hamster, Chinese	CHO-K1 ovary cell line	Chromosomal damage	Micronucleus formation	–	+	10 µg/mL	$P \leq 0.001$, in the dark +S9 Negative –S9 in the dark or with light irradiation	Roustan *et al.* (2014)
Bovine	Lymphocytes	Chromosomal damage	Sister-chromatid exchange	+	NT	17 µM [3 µg/mL]	$P < 0.05$	Lioi *et al.* (1998)
AMPA								
Hamster, Chinese	CHO-K1 ovary cell line	Chromosomal damage	Micronucleus formation	+	+	0.01 µg/mL	$P \leq 0.05$, in the dark –S9 Highest increase was observed at very low dose (0.0005 µg/mL) –S9 but with light-irradiation ($P < 0.01$)	Roustan *et al.* (2014)
Glyphosate-based formulations								
Bovine	Lymphocytes	Chromosomal damage	Chromosomal aberrations	–	NT	1120 µM [190 µg/mL]	Glyphosate, 62%	Siviková & Dianovský (2006)
Bovine	Lymphocytes	Chromosomal damage	Sister-chromatid exchange	+	–	56 µM [9.5 µg/mL]	Glyphosate, 62% Time of exposure, 24 h $P < 0.01$, –S9, at ≥ 56 µM	Siviková & Dianovský (2006)

[a] +, positive; –, negative; (+), weakly positive

AMPA, aminomethyl phosphonic acid; HIC, highest ineffective concentration; *Hprt*, hypoxanthine guanine phosphoribosyl transferase gene; LEC, lowest effective concentration; NT, not tested

Table 4.5 Genetic and related effects of glyphosate, AMPA, and glyphosate-based formulations in non-mammalian systems in vivo

Phylogenetic class	Species, strain, tissue	End-point	Test	Results[a]	Dose (LED or HID)	Comments	Reference
Glyphosate							
Fish	*Prochilodus lineatus* (sábalo), erythrocytes and gill cells	DNA damage	DNA strand breaks, comet assay	+	0.48 mg/L	Time of exposure 6, 24, and 96 h For erythrocytes, $P = 0.01$ after 6 h, and $P = 0.014$ after 96 h; no significant increase after 24 h For gill cells, $P = 0.02$ only after 6 h at 2.4 mg/L	Moreno *et al.* (2014)
Fish	*Anguilla anguilla* L. (European eel), blood cells	DNA damage	DNA strand breaks, comet assay	+	0.0179 mg/L	Time of exposure 1 and 3 days $P < 0.05$	Guilherme *et al.* (2012b)
Fish	*Danio rerio* (zebrafish), sperm	DNA damage	DNA strand breaks, acridine orange method	+	10 mg/L	After 96 h, DNA integrity was 78.3 ± 3.5%, significantly reduced from control (94.7 ± 0.9%) and 5 mg/L (92.6 ± 1.9%), ($P < 0.05$)	Lopes *et al.* (2014)
Fish	*Oreochromis niloticus* (Nile tilapia) branchial erythrocytes	DNA damage	DNA strand breaks, comet assay	+	7 µM [1.2 mg/L]	Time of exposure, 10 days $P < 0.001$ with concentrations ≥ 7 µM	Alvarez-Moya *et al.* (2014)
Oyster	Oyster spermatozoa	DNA damage	DNA strand breaks, comet assay	–	0.005 mg/L	Time of exposure, 1 h	Akcha *et al.* (2012)
Insect	*Drosophila* standard cross	Mutation	SMART	+	1 mM [0.169 mg/L]	Purity, 96% Increased frequency of small single spots (≥ 1 mM) and total spots (≥ 2 mM) $P = 0.05$	Kaya *et al.* (2000)
Insect	*Drosophila melanogaster*, high bioactivation cross	Mutation	SMART	–	10 mM [1.69 mg/L]	Purity, 96%	Kaya *et al.* (2000)

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Table 4.5 (continued)

Phylogenetic class	Species, strain, tissue	End-point	Test	Results[a]	Dose (LED or HID)	Comments	Reference
Plant systems	*Tradescantia* clone 4430 (spiderworts), staminal hair nuclei	DNA damage	DNA strand breaks, comet assay	+	0.0007 mM [0.12 µg/mL]	Glyphosate isopropylamine salt $P < 0.01$ for directly exposed nuclei (dose-dependent increase) and plants	Alvarez-Moya *et al.* (2011)
Plant systems	*Allium cepa* (onion)	Chromosomal damage	Chromosomal aberrations	+	3%	Single dose tested only Partial but significant reversal with distilled water	Frescura *et al.* (2013)
Plant systems	*Allium cepa* (onion)	Chromosomal damage	Chromosomal aberrations	–	2.88 µg/mL	Glyphosate isopropylamine	Rank *et al.* (1993)
Plant systems	*Trigonella foenum-graecum* L. (fenugreek)	Chromosomal damage	Chromosomal aberrations	+	0.2%	$P < 0.001$; positive dose–response relationship	Siddiqui *et al.* (2012)
Plant systems	*Vicia faba* (bean)	Chromosomal damage	Micronucleus formation	–	1400 ppm (1400 µg/g of soil)	Tested with two types of soil, but not without soil	De Marco *et al.* (1992)
AMPA							
Fish	*Anguilla anguilla* L. (European eel)	DNA damage	DNA strand breaks, comet assay	+	0.0118 mg/L	Time of exposure, 1 and 3 days $P < 0.05$ after 1 day of exposure	Guilherme *et al.* (2014b)
Fish	*Anguilla anguilla* L. (European eel)	Chromosomal damage	Other (ENA)	+	0.0236 mg/L	$P < 0.05$ only at highest dose after 3 day exposure (not after 1 day)	Guilherme *et al.* (2014b)
Glyphosate-based formulations							
Fish	*Anguilla anguilla* L. (European eel), blood cells	DNA damage	DNA strand breaks, comet assay	+	0.058 mg/L	$P < 0.05$ Positive dose–response relationship	Guilherme *et al.* (2010)
Fish	*Anguilla anguilla* L. (European eel), blood cells	DNA damage	DNA strand breaks, comet assay improved with the DNA-lesion-specific FPG and Endo III	+	0.058 mg/L	Glyphosate-based formulation, 30.8% Time of exposure, 1 and 3 days With FPG, $P < 0.05$; with comet assay alone, $P < 0.05$ at 116 µg/L	Guilherme *et al.* (2012b)

Table 4.5 (continued)

Phylogenetic class	Species, strain, tissue	End-point	Test	Results[a]	Dose (LED or HID)	Comments	Reference
Fish	*Anguilla anguilla* L. (European eel), blood cells	DNA damage	DNA strand breaks, comet assay improved with the DNA-lesion-specific FPG and Endo III	+	0.116 mg/L	Single dose tested only Time of exposure, 3 days; recovery from non-specific DNA damage, but not oxidative DNA damage, 14 days after exposure $P < 0.05$	Guilherme *et al.* (2014a)
Fish	*Anguilla anguilla* L. (European eel), liver	DNA damage	DNA strand breaks, comet assay improved with the DNA-lesion-specific FPG and Endo III	+	0.058 mg/L	Glyphosate-based formulation, 485 g/L Time of exposure, 3 days $P < 0.05$	Marques *et al.* (2014, 2015)
Fish	*Prochilodus lineatus* (sábalo), erythrocytes and bronchial cells	DNA damage	DNA strand breaks, comet assay	+	10 mg/L	Single dose tested only, for 6, 24, and 96 h $P < 0.05$ for both erythrocytes and bronchial cells	Cavalcante *et al.* (2008)
Fish	*Prochilodus lineatus* (sábalo), erythrocytes and gill cells	DNA damage	DNA strand breaks, comet assay	+	1 mg/L	Glyphosate-based formulation, 480 g/L Time of exposure, 6, 24 and 96 h $P < 0.001$ after 24 and 96 h in erythrocytes and 24 h in gill cells	Moreno *et al.* (2014)
Fish	*Poecilia reticulata* (guppy) gill erythrocytes	DNA damage	DNA strand breaks, comet assay	+	2.83 µL/L [1.833 mg/L]	Glyphosate, 64.8%, m/v (648 g/L) $P < 0.05$	De Souza Filho *et al.* (2013)
Fish	*Channa punctatus* (bloch), blood and gill cells	DNA damage	DNA strand breaks, comet assay	+	3.25 mg/L	Exposure continued for 35 days; blood and gill cells collected on day 1, 7, 14, 21, 28 and 35 $P < 0.01$, for blood and gill cells; DNA damage increased with time and concentration	Nwani *et al.* (2013)

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Table 4.5 (continued)

Phylogenetic class	Species, strain, tissue	End-point	Test	Results[a]	Dose (LED or HID)	Comments	Reference
Fish	*Corydoras paleatus* (blue leopard corydoras, mottled corydoras and peppered catfish), blood and hepatic cells	DNA damage	DNA strand breaks, comet assay	+	0.0067 mg/L	Glyphosate, 48% (corresponding to 3.20 µg/L) Single dose tested only, for 3, 6, and 9 days $P < 0.01$, in blood and in liver cells	de Castilhos Ghisi & Cestari (2013)
Fish	*Cyprinus carpio* Linnaeus (carp), erythrocytes	DNA damage	DNA strand breaks, comet assay	+	2 mg/L (10% LC_{50}, 96 h)	Glyphosate, equivalent to 360 g/L Single dose tested only, for 16 days $P < 0.01$	Gholami-Seyedkolaei *et al.* (2013)
Fish	*Carassius auratus* (goldfish), erythrocytes	DNA damage	DNA strand breaks, comet assay	+	5 ppm	Glyphosate equivalent to 360 g/L Time of exposure, 2, 4 and 6 days After 48 h: $P < 0.05$ (5 mg/L) and $P < 0.001$ (10 and 15 mg/L)	Cavaş & Könen (2007)
Fish	*Prochilodus lineatus* (sábalo) erythrocytes	Chromosomal damage	Micronucleus formation	–	10 mg/L	Single dose tested only, for 6, 24, and 96 h Nuclear abnormalities (lobed nuclei, segmented nuclei and kidney-shaped nuclei)	Cavalcante *et al.* (2008)
Fish	*Corydoras paleatus* (blue leopard corydoras, mottled corydoras and peppered catfish), blood and hepatic cells	Chromosomal damage	Micronucleus formation	–	0.0067 mg/L	Glyphosate, 48% (corresponding to 3.20 µg/L) Single dose tested only, for 3, 6 and 9 days	de Castilhos Ghisi & Cestari (2013)

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Table 4.5 (continued)

Phylogenetic class	Species, strain, tissue	End-point	Test	Results[a]	Dose (LED or HID)	Comments	Reference
Fish	*Tilapia rendalli* (redbreast tilapia) blood erythrocytes	Chromosomal damage	Micronucleus formation	+	42 mg/kg bw	Glyphosate, 480 g/L Increased frequency of micronucleus formation vs control ($P < 0.05$) in blood samples collected 4 days after a single intra-abdominal injection of 42, 85, or 170 mg/kg bw	Grisolia (2002)
Fish	*Carassius auratus* (goldfish), erythrocytes	Chromosomal damage	Micronucleus formation	+	5 ppm	Glyphosate equivalent to 360 g/L Time of exposure, 2, 4 and 6 days Statistically significant differences: 96 h ($P < 0.05$); 144 h ($P < 0.01$)	Cavaş & Könen (2007)
Fish	*Poecilia reticulata* (guppy) gill erythrocytes	Chromosomal damage	Micronucleus formation, ENA	+	1.41 µL/L [0.914 mg/L]	Glyphosate, 64.8%, m/v (648 g/L) Micronucleus formation, $P < 0.01$ Other nuclear abnormalities, $P < 0.05$ at 1.41 to 5.65 µL/L; concentration-dependent ($r^2 = 0.99$)	De Souza Filho *et al.* (2013)
Fish	*Cnesterodon decemmaculatus* (Jenyns, 1842) peripheral blood erythrocytes	Chromosomal damage	Micronucleus formation	+	3.9 mg/L	Glyphosate, 48% Time of exposure, 48 and 96 h $P < 0.05$, with 3.9 and 7.8 mg/L for 48 and 96 h	Vera-Candioti *et al.* (2013)
Fish	*Cnesterodon decemmaculatus* (Jenyns, 1842) peripheral blood erythrocytes	Chromosomal damage	Micronucleus formation	+	22.9 mg/L	Glyphosate, 48% Time of exposure, 48 and 96 h $P < 0.01$, with 22.9 and 45.9 mg/L, and $P < 0.05$ at 68.8 mg/L, for 96 h	Vera-Candioti *et al.* (2013)

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Table 4.5 (continued)

Phylogenetic class	Species, strain, tissue	End-point	Test	Results[a]	Dose (LED or HID)	Comments	Reference
Fish	*Prochilodus lineatus* (sábalo) erythrocytes	Chromosomal damage	Chromosomal aberrations	–	10 mg/L	Single dose tested only, for 6, 24, and 96 h Nuclear abnormalities (lobed nuclei, segmented nuclei and kidney-shaped nuclei)	Cavalcante *et al.* (2008)
Fish	*Anguilla anguilla* L. (European eel), peripheral mature erythrocytes	Chromosomal damage	Other (ENA)	+	0.058 mg/L	Time of exposure, 1 and 3 days Chromosomal breakage and/or chromosomal segregational abnormalities after 3 days of exposure, $P < 0.05$	Guilherme *et al.* (2010)
Caiman	*Caiman latirostris* (broad-snouted caiman), erythrocytes	DNA damage	DNA strand breaks, comet assay	+	0.500 mg/egg	Glyphosate, 66.2% In-ovo exposure; blood sampling at the time of hatching $P < 0.05$ in both experiments (50–1000 µg/egg in experiment 1; 500–1750 µg/egg in experiment 2)	Poletta *et al.* (2009)
Caiman	*Caiman latirostris* (broad-snouted caiman), erythrocytes	DNA damage	DNA strand breaks, comet assay	–	19 800 mg/L	Glyphosate, 66.2% Single dose tested only; in-ovo exposure First spraying exposure at the beginning of incubation period, a second exposure on day 35, then incubation until hatching	Poletta *et al.* (2011)
Caiman	*Caiman latirostris* (broad-snouted caiman), erythrocytes	Chromosomal damage	Micronucleus fomation	+	0.500 mg/egg	Glyphosate, 66.2% In-ovo exposure; blood sampling at the time of hatching $P < 0.05$ in both experiments (50–1000 µg/egg in experiment 1; 500–1750 µg/egg in experiment 2)	Poletta *et al.* (2009)

Table 4.5 (continued)

Phylogenetic class	Species, strain, tissue	End-point	Test	Results[a]	Dose (LED or HID)	Comments	Reference
Caiman	*Caiman latirostris* (broad-snouted caiman), erythrocytes	Chromosomal damage	Micronucleus fomation	+	19.8 g/L	Glyphosate, 66.2% One dose tested; in-ovo exposure First spraying exposure at the beginning of incubation period, a second exposure on day 35, then incubation until hatching. Micronucleus formation, $P < 0.001$ Damage index, $P < 0.001$	Poletta *et al.* (2011)
Frog tadpole	*Rana catesbeiana* (ouaouaron), blood	DNA damage	DNA strand breaks, comet assay	+	1.687 mg/L, p.o.	Time of exposure, 24 h $P < 0.05$, with 6.75 mg/L; and $P < 0.001$ with 27 mg/L (with 108 mg/L, all died within 24 h)	Clements *et al.* (1997)
Frog	*Eleutherodactylus johnstonei* (Antilles coqui), erythrocytes	DNA damage	DNA strand breaks, comet assay	+	0.5 µg a.e./cm²	Glyphosate-based formulation, 480 g/L Exposure to an homogenate mist in a 300 cm² glass terrarium Time of exposure: 0.5, 1, 2, 4, 8 and 24 h $P < 0.05$	Meza-Joya *et al.* (2013)
Frog	*Euflictis cyanophlyctis* (Indian skittering frog), erythrocytes	Chromosomal damage	Micronucleus formation	+	1 mg a.e./L	Glyphosate isopropylamine salt, 41% Time of exposure: 24, 48, 72, and 96 h $P < 0.001$ at 24, 48, 72 and 96 h	Yadav *et al.* (2013)
Snail	*Biomphalaria alexandrina*, haemolymph	DNA damage	DNA strand breaks, comet assay	+	10 mg/L	Glyphosate, 48% Single dose tested only, for 24 h. The percentage of damaged DNA was 21% vs 4% (control) No statistical analysis	Mohamed (2011)
Oyster	Oysters, spermatozoa	DNA damage	DNA strand breaks, comet assay	–	5 µg/L	Glyphosate, 200 µg equivalent/L Time of exposure, 1 h	Akcha *et al.* (2012)

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Table 4.5 (continued)

Phylogenetic class	Species, strain, tissue	End-point	Test	Results[a]	Dose (LED or HID)	Comments	Reference
Clam	*Corbicula fluminea* (Asian clam) haemocytes	DNA damage	DNA strand breaks, comet assay	–	10 mg/L	Time of exposure, 96 h Significant increase when atrazine (2 or 10 mg/L) was added to glyphosate ($P < 0.05$) No increase after exposure to atrazine or glyphosate separately	dos Santos & Martinez (2014)
Mussels	*Utterbackia imbecillis* (Bivalvia: Unionidae) glochidia mussels (larvae)	DNA damage	DNA strand breaks, comet assay	–	5 mg/L	Glyphosate, 18% Doses tested: 2.5 and 5 mg/L for 24 h NOEC, 10.04 mg/L	Conners & Black (2004)
Worm	Earthworm, *Eisenia andrei*, coelomocytes	DNA damage	DNA strand breaks, comet assay	–	240 µg a.e./cm²	Monoammonium salt, 85.4%, a.e. Epidermic exposure during 72 h (on filter paper)	Piola *et al.* (2013)
Worm	Earthworm, *Eisenia andrei*, coelomocytes	DNA damage	DNA strand breaks, comet assay	+	15 µg a.e./cm²	Monoammonium salt, 72%, a.e. Epidermic exposure during 72 h (on filter paper) $P < 0.001$	Piola *et al.* (2013)
Worm	Earthworm, *Pheretima peguana*, coelomocytes	DNA damage	DNA strand breaks, comet assay	–	251.50 µg/cm²	Active ingredient, 36% (w/v) Epidermic exposure 48 h on filter paper; LC_{50}, 251.50 µg/cm²	Muangphra *et al.* (2014)
Worm	Earthworm, *Pheretima peguana*, coelomocytes	Chromosomal damage	Micronucleus formation	+	251.50 µg/cm²	Active ingredient, 36% (w/v) Exposure, 48 h on filter paper; LC_{50}, 251.50 µg/cm² filter paper $P < 0.05$, for total micro-, bi-, and trinuclei frequencies at 0.25 µg/cm²; when analysed separately, micro- and trinuclei frequencies significantly differed from controls only at the LC_{50}	Muangphra *et al.* (2014)

Table 4.5 (continued)

Phylogenetic class	Species, strain, tissue	End-point	Test	Results[a]	Dose (LED or HID)	Comments	Reference
Insect	*Drosophila melanogaster*	Mutation	Sex-linked recessive lethal mutations	+	1 ppm	Single dose tested only $P < 0.001$	Kale *et al.* (1995)
Plant systems	*Allium cepa* (onion)	Chromosomal damage	Chromosomal aberrations	+	1.44 µg/mL	Glyphosate-based formulation, 480 g/L The doses of formulation were calculated as glyphosate isopropylamine $P < 0.005$	Rank *et al.* (1993)
Plant systems	*Crepis capillaris* (hawksbeard)	Chromosomal damage	Chromosomal aberrations	–	0.5%	The highest dose tested (1%) was toxic	Dimitrov *et al.* (2006)
Plant systems	*Hordeum vulgare* L. cv. Madalin (barley roots)	Chromosomal damage	Chromosomal aberrations	(+)	360 µg/mL (0.1%)	Reported as "significant"	Truta *et al.* (2011)
Plant systems	*Crepis capillaris* (hawksbeard)	Chromosomal damage	Micronucleus formation	–	0.5%	The highest dose tested (1%) was toxic	Dimitrov *et al.* (2006)

[a] +, positive; –, negative; (+) or (–) positive/negative in a study with limited quality

a.e., acid equivalent; AMPA, aminomethyl phosphonic acid; bw, body weight; ENA, erythrocytic nuclear abnormalities; Endo III, endonuclease III; FPG, formamidopyrimidine glycosylase; h, hour; HID, highest ineffective dose; LC_{50}, median lethal dose; LED, lowest effective dose; NOEC, no-observed effect concentration; p.o., oral; SMART, somatic mutation and recombination test

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Table 4.6 Genetic and related effects of glyphosate and glyphosate-based formulations on non-mammalian systems in vitro

Phylogenetic class	Test system (species; strain)	End-point	Test	Results[a]		Concentration (LEC or HIC)	Comments	Reference
				Without metabolic activation	With metabolic activation			
Glyphosate								
Eukaryote Fish	*Oreochromis niloticus* (Nile tilapia), erythrocytes	DNA damage	DNA strand breaks, comet assay	+	NT	7 µM [1.2 µg/mL]	Glyphosate isopropylamine, 96% $P \leq 0.001$; positive dose–response relationship for doses ≥ 7 µM	Alvarez-Moya *et al.* (2014)
Prokaryote (bacteria)	*Scytonema javanicum* (cyanobacteria)	DNA damage	DNA strand breaks, FADU assay	(+)	NT	10 µM [1.7 µg/mL] (in combination with UVB)	Co-exposure to glyphosate (not tested alone; single dose tested only) enhanced UVB-induced increases	Wang *et al.* (2012)
Prokaryote (bacteria)	*Anabaena spherica* (cyanobacteria)	DNA damage	DNA strand breaks, FADU assay	(+)	NT	10 µM [1.7 µg/mL] (in combination with UVB)	Co-exposure to glyphosate (not tested alone; single dose tested only) enhanced UVB-induced increases	Chen *et al.* (2012)
Prokaryote (bacteria)	*Microcystis viridis* (cyanobacteria)	DNA damage	DNA strand breaks, FADU assay	(+)	NT	10 µM [1.7 µg/mL] (in combination with UVB)	Co-exposure to glyphosate (not tested alone; single dose tested only) enhanced UVB-induced increases	Chen *et al.* (2012)
Prokaryote (bacteria)	*Bacillus B. subtilis*	Differential toxicity	Rec assay	–	NT	2000 µg/disk		Li & Long (1988)
Prokaryote (bacteria)	*Salmonella typhimurium* TA1535, TA1537, TA1538, TA98 and TA100	Mutation	Reverse mutation	–	–	5000 µg/plate		Li & Long (1988)
Prokaryote (bacteria)	*Escherichia coli* WP2	Mutation	Reverse mutation	–	–	5000 µg/plate		Li & Long (1988)

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Table 4.6 (continued)

Phylogenetic class	Test system (species; strain)	End-point	Test	Results[a]		Concentration (LEC or HIC)	Comments	Reference
				Without metabolic activation	With metabolic activation			
Acellular systems	Prophage superhelical PM2 DNA	DNA damage	DNA strand breaks	(–)	NT	75 mM [12.7 mg/mL] (in combination with H_2O_2 (100 µM)	Glyphosate inhibited H_2O_2-induced damage of PM2 DNA at concentrations where synergism was observed in cellular DNA damage (data NR)	Lueken *et al.* (2004)
Glyphosate-based formulations								
Prokaryote (bacteria)	*Salmonella typhimurium* TA98	Mutation	Reverse mutation	+	–	360 µg/plate	Glyphosate isopropylammonium salt, 480 g/L	Rank *et al.* (1993)
Prokaryote (bacteria)	*Salmonella typhimirium* TA100	Mutation	Reverse mutation	–	+	720 µg/plate	Glyphosate isopropylammonium salt, 480 g/L	Rank *et al.* (1993)

[a] +, positive; –, negative; (+) or (–) positive/negative in a study with limited quality

FADU, fluorometric analysis of DNA unwinding; HIC, highest ineffective concentration; LEC, lowest effective concentration; NR, not reported; NT, not tested; UVB, ultraviolet B

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Additionally, although all four glyphosate-based formulations dramatically reduced the transcription of ERα and ERβ in ERE-transfected HepG2 cells, glyphosate alone had no significant effect. Glyphosate and all four formulations reduced androgen-receptor transcription in the breast cancer cell line MDA-MB453-kb2, which has a high level of androgen receptor, with the formulations showing greater activity than glyphosate alone.

In a human placental cell line derived from choriocarcinoma (JEG3 cells), 18 hours of exposure to a glyphosate-based formulation (IC_{50} = 0.04%) decreased aromatase activity (Richard *et al.*, 2005). Glyphosate alone was without effect. The concentrations used did not affect cell viability.

Glyphosate, at non-overtly toxic concentrations, decreased aromatase activity in fresh human placental microsomes and transformed human embryonic kidney cells (293) transfected with human aromatase cDNA (Benachour *et al.*, 2007). A glyphosate-based formulation, at non-overtly toxic concentrations, had the same effect. The formulation was more active at equivalent doses than glyphosate alone.

In human androgen receptor and ERα and ERβ reporter gene assays using the Chinese hamster ovary cell line (CHO-K1), glyphosate had neither agonist nor antagonist activity (Kojima *et al.*, 2004, 2010).

(ii) Non-human mammalian experimental systems

In vivo

No data were available to the Working Group.

In vitro

Benachour *et al.* (2007) and Richard *et al.* (2005) reported that glyphosate and a glyphosate-based formulation inhibited aromatase activity in microsomes derived from equine testis. Richard *et al.* (2005) reported an absorbance spectrum consistent with an interaction between a nitrogen atom of glyphosate and the active site of the purified equine aromatase enzyme.

In the mouse MA-10 Leydig cell tumour cell line, a glyphosate-based formulation (glyphosate, 180 mg/L) markedly reduced [$(Bu)_2$] cAMP-stimulated progesterone production (Walsh *et al.*, 2000). The inhibition was dose-dependent, and occurred in the absence of toxicity or parallel reductions in total protein synthesis. In companion studies, the formulation also disrupted steroidogenic acute regulatory protein expression, which is critical for steroid hormone synthesis. Glyphosate alone did not affect steroidogenesis at any dose tested up to 100 µg/L. Forgacs *et al.* (2012) found that glyphosate (300 µM) had no effect on testosterone production in a novel murine Leydig cell line (BLTK1). Glyphosate did not modulate the effect of recombinant human chorionic gonadotropin, which served as the positive control for testosterone production.

(iii) Non-mammalian experimental systems

Gonadal tissue levels of testosterone, 17β-estradiol and total microsomal protein were significantly reduced in adult snails (*Biomphalaria alexandrina*) exposed for 3 weeks to a glyphosate-based formulation (glyphosate, 48%) at the LC_{10} (10% lethal concentration) (Omran & Salama, 2013). These effects persisted after a 2-week recovery period, although the impact on 17β-estradiol was reduced in the recovery animals. The formulation also induced marked degenerative changes in the ovotestis, including absence of almost all the gametogenesis stages. CYP450 1B1, measured by enzyme-linked immunosorbent assay (ELISA), was substantially increased in the treated snails, including after the recovery period.

Glyphosate (0.11 mg/L for 7 days) did not increase plasma vittelogenin levels in juvenile rainbow trout (Xie *et al.*, 2005).

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(b) Other pathways

(i) Humans

Studies in exposed humans

No data were available to the Working Group.

Human cells in vitro

Glyphosate did not exhibit agonist activity in an assay for a human pregnane X receptor (PXR) reporter gene in a CHO-K1 cell line (Kojima *et al.*, 2010).

(ii) Non-human mammalian experimental systems

In vivo

In rats, glyphosate (300 mg/kg bw, 5 days per week, for 2 weeks) had no effect on the formation of peroxisomes, or the activity of hepatic carnitine acetyltransferase and catalase, and did not cause hypolipidaemia, suggesting that glyphosate does not have peroxisome proliferator-activated receptor activity (Vainio *et al.*, 1983).

In vitro

Glyphosate was not an agonist for mouse peroxisome proliferator-activated receptors PPARα or PPARγ in reporter gene assays using CV-1 monkey kidney cells in vitro (Kojima *et al.*, 2010). Glyphosate was also not an agonist for the aryl hydrocarbon receptor in mouse hepatoma Hepa1c1c7 cells stably transfected with a reporter plasmid containing copies of dioxin-responsive element (Takeuchi *et al.*, 2008).

(iii) Non-mammalian experimental systems

As a follow-up to experiments in which injection of glyphosate, or incubation with a glyphosate-based formulation (glyphosate, 48%), caused chick and frog (*Xenopus laevis*) cephalic and neural crest terata characteristic of retinoic acid signalling dysfunction, Paganelli *et al.*, (2010) measured retinoic acid activity in tadpoles exposed to a glyphosate-based formulation. Retinoic activity measured by a reporter gene assay was increased by the formulation, and a retinoic acid antagonist blocked the effect. This indicated a possible significant modulation of retinoic acid activity by glyphosate.

4.2.3 Oxidative stress, inflammation, and immunosuppression

(a) Oxidative stress

(i) Humans

Studies in exposed humans

No data were available to the Working Group.

Human cells in vitro

Several studies examined the effects of glyphosate on oxidative stress parameters in the human keratinocyte cell line HaCaT. Gehin *et al.* (2005) found that a glyphosate-based formulation was cytotoxic to HaCaT cells, but that addition of antioxidants reduced cytotoxicity. Elie-Caille *et al.* (2010) showed that incubation of HaCaT cells with glyphosate at 21 mM (the half maximal inhibitory concentration for cytotoxicity, IC_{50}) for 18 hours increased production of hydrogen peroxide (H_2O_2) as shown by dichlorodihydrofluorescein diacetate assay. Similarly, George & Shukla (2013) exposed HaCaT cells to a glyphosate-based formulation (glyphosate, 41%; concentration, up to 0.1 mM) and evaluated oxidative stress using the dichlorodihydrofluorescein diacetate assay. The formulation (0.1 mM) increased maximum oxidant levels by approximately 90% compared with vehicle, an effect similar to that of H_2O_2 (100 mM). Pre-treatment of the cells with the antioxidant *N*-acetylcysteine abrogated generation of oxidants by both the formulation and by H_2O_2. *N*-Acetylcysteine also inhibited cell proliferation induced by the glyphosate-based formulation (0.1 mM). [The Working Group noted the recognized limitations of using dichlorodihydrofluorescein diacetate as a marker of oxidative stress (Bonini *et al.*, 2006; Kalyanaraman *et al.*, 2012),

and that the studies that reported this end-point as the sole evidence for oxidative stress should thus be interpreted with caution.]

Chaufan *et al.* (2014) evaluated the effects of glyphosate, AMPA (the main metabolite of glyphosate), and a glyphosate-based formulation on oxidative stress in HepG2 cells. The formulation, but not glyphosate or AMPA, had adverse effects. Specifically, the formulation increased levels of reactive oxygen species, nitrotyrosine formation, superoxide dismutase activity, and glutathione, but did not have an effect on catalase or glutathione-*S*-transferase activities. Coalova *et al.* (2014) exposed Hep2 cells to a glyphosate-based formulation (glyphosate as isopropylamine salt, 48%) at the LC_{20} (concentration not otherwise specified) and evaluated various parameters of oxidative stress. Exposure to the formulation for 24 hours increased catalase activity and glutathione levels, but did not have an effect on superoxide dismutase or glutathione-*S*-transferase activity.

Using blood samples from non-smoking male donors, Mladinic *et al.* (2009b) examined the effects of in-vitro exposure to glyphosate on oxidative DNA damage in primary lymphocyte cultures and on lipid peroxidation in plasma. Both parameters were significantly elevated at glyphosate concentrations of 580 µg/mL (~3.4 mM), but not at lower concentrations. Kwiatkowska *et al.* (2014) examined the effects of glyphosate, its metabolite AMPA, and *N*-methylglyphosate (among other related compounds) in human erythrocytes isolated from healthy donors. The erythrocytes were exposed at concentrations of 0.01–5 mM for 1, 4, or 24 hours before flow cytometric measurement of the production of reactive oxygen species with dihydrorhodamine 123. Production of reactive oxygen species was increased by glyphosate (≥ 0.25 mM), AMPA (≥ 0.25 mM), and *N*-methylglyphosate (≥ 0.5 mM).

(ii) Non-human mammalian experimental systems

Most of the studies of oxidative stress and glyphosate were conducted in rats and mice, and examined a range of exposure durations, doses, preparations (glyphosate and glyphosate-based formulations), administration routes and tissues. In addition, various end-points were evaluated to determine whether oxidative stress is induced by exposure to glyphosate. Specifically, it was found that glyphosate induces production of free radicals and oxidative stress in mouse and rat tissues through alteration of antioxidant enzyme activity, depletion of glutathione, and increases in lipid peroxidation. Increases in biomarkers of oxidative stress upon exposure to glyphosate in vivo have been observed in blood plasma (Astiz *et al.*, 2009b), liver (Bolognesi *et al.*, 1997; Astiz *et al.*, 2009b), skin (George *et al.*, 2010), kidney (Bolognesi *et al.*, 1997; Astiz *et al.*, 2009b), and brain (Astiz *et al.*, 2009b). Several studies demonstrated similar effects with a glyphosate-based formulation in the liver (Bolognesi *et al.*, 1997; Cavuşoğlu *et al.*, 2011; Jasper *et al.*, 2012), kidney (Bolognesi *et al.*, 1997; Cavuşoğlu *et al.*, 2011) and brain (Cattani *et al.*, 2014), or with a pesticide mixture containing glyphosate in the testes (Astiz *et al.*, 2013). Pre-treatment with antioxidants has been shown to mitigate the induction of oxidative stress by a glyphosate-based formulation (Cavuşoğlu *et al.*, 2011) and by a pesticide mixture containing glyphosate (Astiz *et al.*, 2013).

DNA damage associated with oxidative stress after exposure to glyphosate (e.g. as reported in Bolognesi *et al.*, 1997) is reviewed in Section 4.2.1.

(iii) Non-mammalian experimental systems

Positive associations between exposure to glyphosate and oxidative stress were reported in various tissues in aquatic organisms (reviewed in Slaninova *et al.*, 2009). Glyphosate and various glyphosate-based formulations have been tested in various fish species for effects on a plethora of end-points (e.g. lipid peroxidation, DNA

damage, expression of antioxidant enzymes, levels of glutathione), consistently presenting evidence that glyphosate can cause oxidative stress in fish (Lushchak *et al.*, 2009; Ferreira *et al.*, 2010; Guilherme *et al.*, 2010, 2012a, b, 2014a, b; Modesto & Martinez, 2010a, b; Cattaneo *et al.*, 2011; Glusczak *et al.*, 2011; de Menezes *et al.*, 2011; Ortiz-Ordoñez *et al.*, 2011; Nwani *et al.*, 2013; Marques *et al.*, 2014, 2015; Sinhorin *et al.*, 2014; Uren Webster *et al.*, 2014). Similar effects were observed in bullfrog tadpoles exposed to a glyphosate-based formulation (Costa *et al.*, 2008), and in the Pacific oyster exposed to a pesticide mixture containing glyphosate (Geret *et al.*, 2013).

(b) Inflammation and immunomodulation

(i) Humans

Studies in exposed humans

No data were available to the Working Group.

Human cells in vitro

Nakashima *et al.* (2002) investigated the effects of glyphosate on cytokine production in human peripheral blood mononuclear cells. Glyphosate (1 mM) had a slight inhibitory effect on cell proliferation, and modestly inhibited the production of IFN-gamma and IL-2. The production of TNF-α and IL-1 β was not affected by glyphosate at concentrations that significantly inhibited proliferative activity and T-cell-derived cytokine production.

(ii) Non-human mammalian experimental systems

Kumar *et al.* (2014) studied the pro-inflammatory effects of glyphosate and farm air samples in wildtype C57BL/6 and TLR4$^{-/-}$ mice, evaluating cellular response, humoral response, and lung function. In the bronchoalveolar lavage fluid and lung digests, airway exposure to glyphosate (1 or 100 µg) significantly increased the total cell count, eosinophils, neutrophils, and IgG1 and IgG2a levels. Airway exposure to glyphosate (100 ng, 1 µg, or 100 µg per day for 7 days) also produced substantial pulmonary inflammation, confirmed by histological examination. In addition, glyphosate-rich farm-air samples significantly increased circulating levels of IL-5, IL-10, IL-13 and IL-4 in wildtype and in TLR4$^{-/-}$ mice. Glyphosate was also tested in wildtype mice and significantly increased levels of IL-5, IL-10, IL-13, and IFN-γ (but not IL-4). The glyphosate-induced pro-inflammatory effects were similar to those induced by ovalbumin, and there were no additional or synergistic effects when ovalbumin was co-administered with glyphosate.

Pathological effects of glyphosate on the immune system have been reported in 13-week rat and mouse feeding studies by the NTP (Chan & Mahler, 1992). Relative thymus weight was decreased in male rats exposed for 13 weeks, but increased in male mice. Treatment-related changes in haematological parameters were observed in male rats at 13 weeks and included mild increases in haematocrit [erythrocyte volume fraction] and erythrocytes at 12 500, 25 000, and 50 000 ppm, haemoglobin at 25 000 and 50 000 ppm, and platelets at 50 000 ppm. In female rats, small but significant increases occurred in lymphocyte and platelet counts, leukocytes, mean corpuscular haemoglobin, and mean corpuscular volume at 13 weeks.

Blakley (1997) studied the humoral immune response in female CD-1 mice given drinking-water containing a glyphosate-based formulation at concentrations up to 1.05% for 26 days. The mice were inoculated with sheep erythrocytes to produce a T-lymphocyte, macrophage-dependent antibody response on day 21 of exposure. Antibody production was not affected by the formulation.

(iii) Non-mammalian experimental systems

A positive association between exposure to glyphosate and immunotoxicity in fish has been reported. Kreutz *et al.* (2011) reported alterations

in haematological and immune-system parameters in silver catfish (*Rhamdia quelen*) exposed to sublethal concentrations (10% of the median lethal dose, LC_{50}, at 96 hours) of a glyphosate-based herbicide. Numbers of blood erythrocytes, thrombocytes, lymphocytes, and total leukocytes were significantly reduced after 96 hours of exposure, while the number of immature circulating cells was increased. The phagocytic index, serum bacteria agglutination, and total peroxidase activity were significantly reduced after 24 hours of exposure. Significant decreases in serum bacteria agglutination and lysozyme activity were found after 10 days of exposure. No effect on serum bactericidal and complement natural haemolytic activity was seen after 24 hours or 10 days of exposure to glyphosate.

el-Gendy *et al.* (1998) demonstrated effects of a glyphosate-based formulation (glyphosate, 48%) at 1/1000 of the concentration recommended for field application on humoral and cellular immune response in bolti fish (*Tilapia nilotica*). The mitogenic responses of splenocytes to phytohaemagglutinin, concanavalin A, and lipopolysaccharide in fish exposed to glyphosate for 96 hours were gradually decreased and reached maximum depression after 4 weeks. Glyphosate also produced a concentration-dependent suppression of in-vitro plaque-forming cells in response to sheep erythrocytes.

4.2.4 Cell proliferation and death

(a) Humans

(i) Studies in exposed humans

No data were available to the Working Group.

(ii) Human cells in vitro

Cell proliferation potential was explored in HaCaT keratinocytes exposed to a glyphosate-based formulation (glyphosate, 41%; concentration, up to 0.1 mM) (George & Shukla, 2013). The formulation increased the number of viable cells, as assessed by the MTT assay (based on reduction of the dye 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) at concentrations up to 0.1 mM, while concentration- and incubation-time-dependent reductions were seen at higher concentrations (up to 1 mM). The formulation (0.01 or 0.1 mM for 72 hours) significantly enhanced cell proliferation (measured by staining for either proliferating cell nuclear antigen or 5-bromo-2′-deoxyuridine); at 0.1 mM, the increases exceeded levels for the positive control, tetradecanoyl-phorbol-13-acetate. The proportion of S-phase cells (assessed using flow cytometry) and the expression of G1/S cell-cycle regulatory proteins (cyclins D1 and E, CDK2, CDK4, and CDK6) increased after exposure to the formulation or the positive control.

Li *et al.* (2013) reported that glyphosate and AMPA inhibited cell growth in eight human cancer cell lines, but not in two immortalized normal prostate cell lines. An ovarian (OVCAR-3) and a prostate (C4–2B) cell line showed the greatest loss in viability, with glyphosate or AMPA at 15–50 mM. Further assays were conducted on AMPA, but not glyphosate, in two prostate cancer cell lines (C4–2B and PC-3), and found cell-cycle arrest (decreased entry of cells into S-phase) and increased apoptosis. [The Working Group noted that the findings from these assays with AMPA are of unclear relevance to the effects of glyphosate.]

Glyphosate (10^{-6} to 1 μM) increased growth by 15–30% relative to controls in hormone-dependent T47D breast cancer cells, but only when endogenous estrogen was minimized in the culture medium (by substitution with 10% dextran-charcoal treated fetal bovine serum). Glyphosate did not affect the growth of hormone-independent MDA-MB231 breast cancer cells cultured in either medium (Thongprakaisang *et al.*, 2013).

Glyphosate (up to 30 μM) did not show cell proliferation potential (5-bromo-2′-deoxyuridine) and did not activate caspase 3 or TP53 in human neuroprogenitor ReN CX cells (Culbreth *et al.*, 2012).

Several studies evaluated the impact of glyphosate or glyphosate-based formulations on apoptotic cell death in the HepG2 human hepatoma cell line. Glyphosate-based formulations induced apoptosis in HepG2 cells, while glyphosate alone was generally without effect or showed effects at considerably higher concentrations (Gasnier *et al.*, 2009, 2010; Mesnage *et al.*, 2013; Chaufan *et al.*, 2014; Coalova *et al.*, 2014). For example, 23.5% of the nuclei of HepG2 cells exposed to a glyphosate-based formulation showed condensed and fragmented chromatin ($P < 0.01$), and caspases 3 and 7 were significantly activated, both effects being indicative of apoptosis (Chaufan *et al.*, 2014). Caspases were unaffected by glyphosate or AMPA alone. Glyphosate and AMPA did not affect cell viability at concentrations up to 1000 mg/L, a concentration that increased rather than decreased cell viability after 48 and 72 hours of incubation. In contrast, cells exposed to glyphosate-based formulation at lower concentrations were not viable. Similarly, Coalova *et al.* (2014) reported that a glyphosate-based formulation (glyphosate, 48%) induced apoptotic cell death in HepG2 cells. Apoptosis was indicated by activation of caspases 3 and 7, and the significant fraction (17.7%) of nuclei with condensed and fragmented chromatin ($P < 0.001$).

In studies with glyphosate and nine different glyphosate-based formulations in three cell lines, glyphosate alone did not increase the activity of adenylate kinase (Mesnage *et al.*, 2013). The activity of caspases 3 and 7 was significantly increased by glyphosate in HepG2 and embryonic kidney HEK293 cells, and elevated (although not significantly) about 1.8 times above control levels in placental choriocarcinoma JEG-3 cells. Two formulations containing an ethoxylated adjuvant induced adenylate kinase activity to a greater extent than caspase activity. All formulations were reported to be more cytotoxic than glyphosate. [In concentration–response curves, glyphosate showed an effect on mitochondrial succinate dehydrogenase activity, a measure of cell viability, that was similar to that shown by one formulation. The calculated 50% lethal concentration in JEG3 cells for mitochondrial succinate dehydrogenase activity was greater for three formulations, although the values appeared inconsistent with the concentration–response curves.]

In HUVEC primary neonate umbilical cord vein cells, and 293 embryonic kidney and JEG3 placental cell lines, Benachour & Séralini (2009) found that glyphosate at relatively high concentrations induced apoptosis, as indicated by induction of caspases 3 and 7, and DNA staining and microscopy. At comparable or lower concentrations, four glyphosate-based formulations all caused primarily necrotic cell death. The umbilical cord HUVEC cells were the most sensitive (by about 100-fold) to the apoptotic effects of glyphosate.

Heu *et al.* (2012) evaluated apoptosis in immortalized human keratinocytes (HaCaT) exposed to glyphosate (5–70 mM). Based on annexin V, propidium iodide and mitochondrial staining, exposures leading to 15% cytotoxicity gave evidence of early apoptosis, while increases in late apoptosis and necrosis were observed at higher levels of cytotoxicity.

(b) Non-human mammalian experimental systems

(i) In vivo

In male Wistar rats, glyphosate (10 mg/kg bw, injected intraperitoneally three times per week for 5 weeks) reduced, but not significantly, the inner mitochondrial membrane integrity of the substantia nigra and cerebral cortex (Astiz *et al.* 2009a). Caspase 3 activity was unaltered in these tissues. Mitochondrial cardiolipin content was significantly reduced, particularly in the substantia nigra, where calpain activity was substantially higher. Glyphosate induced DNA fragmentation in the brain and liver.

(ii) In vitro

In adult Sprague Dawley rat testicular cells exposed in vitro, glyphosate (up to 1%; for 24 or 48 hours) did not provoke cell-membrane alterations (Clair *et al.*, 2012). However, caspase 3 and 7 activity increased with exposure in Sertoli cells alone, and in Sertoli and germ cell mixtures. On the other hand, a glyphosate-based formulation (a 0.1% solution, containing 0.36 g/L of glyphosate) induced membrane alterations and decreased the activity of caspase 3 and 7 in Leydig cells, and in Sertoli and germ cell mixtures. In a separate study, glyphosate increased apoptosis in primary Sertoli cell cultures from mice (Zhao *et al.*, 2013).

Glyphosate (5–40 mM, for 12, 24, 48, or 72 hours) significantly increased cell death in a time- and concentration-dependent manner in differentiated rat pheochromocytoma PC12 (neuronal) cells Gui *et al.* (2012). Apoptotic changes included cell shrinkage, DNA fragmentation, decreased Bcl2 expression, and increased Bax expression. Both autophagy and apoptosis were implicated, as pre-treatment with the pan-caspase inhibitor Z-VAD or the autophagy inhibitor 3-MA inhibited cell loss.

Induction of apoptosis by glyphosate or glyphosate-based formulations was also studied in other cell lines. Glyphosate (10 μM) induced apoptosis in rat heart H9c2 cells, the effect being enhanced when glyphosate was given in combination with the adjuvant TN-20 (5 μM), (Kim *et al.*, 2013). A glyphosate-based formulation induced apoptosis in mouse 3T3-L1 fibroblasts, and inhibited their transformation to adipocytes (Martini *et al.*, 2012). A glyphosate-based formulation (10 mM) did not increase rat hepatoma HTC cell death, but did affect mitochondrial membrane potential (Malatesta *et al.*, 2008).

Glyphosate (up to 30 μM) did not activate caspase 3 or show cell proliferation potential (5-bromo-2′-deoxyuridine) in a mouse neuroprogenitor cell line, but did activate Tp53 at the highest concentration tested (Culbreth *et al.*, 2012).

4.2.5 Other mechanisms

No data on immortalization, epigenetic alterations, altered DNA repair, or genomic instability after exposure to glyphosate were available to the Working Group.

4.3 Data relevant to comparisons across agents and end-points

No data on high-throughput screening or other relevant data were available to the Working Group. Glyphosate was not tested by the Tox21 and ToxCast research programmes of the government of the USA (Kavlock *et al.* 2012; Tice *et al.*, 2013).

4.4 Cancer susceptibility data

No studies that examined genetic, life-stage, or other susceptibility factors with respect to adverse health outcomes that could be associated with exposure to glyphosate were identified by the Working Group.

4.5 Other adverse effects

4.5.1 Humans

In the USA in the past decade, poison-control centres have reported more than 4000 exposures to glyphosate-containing herbicides, of which several hundred were evaluated in a health-care facility, and fatalities were rare (Rumack, 2015). In a pesticide surveillance study carried out by the National Poisons Information Service of the United Kingdom, glyphosate was among the most common pesticide exposure implicated in severe or fatal poisoning cases between 2004 and 2013 (Perry *et al.*, 2014). Deliberate poisonings with glyphosate resulting in toxicity and fatality

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have been reported in many countries, including Australia (Stella & Ryan, 2004), Denmark (Mortensen *et al.*, 2000), India (Mahendrakar *et al.*, 2014), Japan (Motojyuku *et al.*, 2008), Republic of Korea (Park *et al.*, 2013), New Zealand (Temple & Smith, 1992), Sri Lanka (Roberts *et al.*, 2010), Taiwan, China (Chen *et al.*, 2009), and Thailand (Sribanditmongkol *et al.*, 2012).

Glyphosate demonstrated no potential for photo-irritation or photo-sensitization in 346 volunteers exposed dermally on normal or abraded skin (Hayes & Laws, 1991). On the other hand, Mariager *et al.* (2013) reported severe burns after prolonged accidental dermal exposure to a glyphosate-based formulation.

4.5.2 Experimental systems

Glyphosate was tested in nine regulatory submissions included in the Toxicity Reference Database (ToxRefDB) and reviewed by the EPA (EPA, 2015). Specifically, study design, treatment group, and treatment-related effect information were captured for four long-term studies and/or carcinogenicity studies, one short-term study, two multigeneration studies of reproductivity, and two studies of developmental toxicity. The NTP also tested glyphosate in a 13-week study in rats and mice (Chan & Mahler, 1992).

In a long-term combined study of toxicity and carcinogenicity in rats given glyphosate at nominal doses of 100, 400, and 1000 mg/kg bw per day, inflammation was observed in the stomach mucosa of females at the intermediate and highest doses (EPA, 1990, 1991b). In males at the highest dose, liver weight, cataracts and lens degeneration in the eyes, and urine specific gravity were increased, while body weight, body-weight gain, and urinary pH were decreased. Pancreatic acinar cell atrophy was observed in males at the highest dose. Pancreatic inflammation was also observed in male rats at the highest dose in a short-term study (nominal doses of 50, 250, and 1000 mg/kg bw per day) (EPA, 1987). In the study by the NTP, cytoplasmic alteration was observed in the parotid and submandibular salivary glands of rats (Chan & Mahler, 1992).

In a study of carcinogenicity in mice given glyphosate at doses of 150, 1500, or 4500 mg/kg bw per day, liver hypertrophy and necrosis were observed in males at the highest dose (EPA, 1983). Other effects in males at the highest dose included increased testes weight, interstitial nephritis, and decreased body weight. In females at the highest dose, ovary weights were increased, proximal tubule epithelial basophilia and hypertrophy was observed, and body weights were decreased. In the study by the NTP, cytoplasmic alteration was observed in the parotid salivary glands in mice (Chan & Mahler, 1992).

Developmental and reproductive toxicity

In a study of developmental toxicity in rats given glyphosate at a dose of 300, 1000, or 3500 mg/kg bw per day, reduced implantation rates and fewer live fetuses were observed in dams at the highest dose (EPA, 1980b). In fetuses at the highest dose, unossified sternebra were observed and fetal weight was reduced.

5. Summary of Data Reported

5.1 Exposure data

Glyphosate is a broad-spectrum herbicide that is effective at killing or suppressing all plant types, including grasses, perennials, and woody plants. The herbicidal activity of glyphosate was discovered in 1970 and since then its use has increased to a point where it is now the most heavily used herbicide in the world, with an annual global production volume in 2012 of more than 700 000 tonnes used in more than 750 different products. Changes in farming practice and the development of genetically modified crops that are resistant to glyphosate have contributed to the increase in use.

There is little information available on occupational or community exposure to glyphosate. Glyphosate can be found in soil, air, surface water and groundwater, as well as in food. It has been detected in air during agricultural herbicide-spraying operations. Glyphosate was detected in urine in two studies of farmers in the USA, in urban populations in Europe, and in a rural population living near areas sprayed for drug eradication in Columbia. However, urinary concentrations were mostly below the limit of detection in several earlier studies of forestry workers who sprayed glyphosate. Exposure of the general population occurs mainly through diet.

5.2 Human carcinogenicity data

In its evaluation of the epidemiological studies reporting on cancer risks associated with exposure to glyphosate, the Working Group identified seven reports from the Agricultural Health Study (AHS) cohort and several reports from case–control studies. The AHS cohort, the pooled analyses of the case–control studies in the midwest USA, and the cross-Canada study were considered key investigations because of their relatively large size. Reports from two or more independent studies were available for non-Hodgkin lymphoma (NHL), multiple myeloma, Hodgkin lymphoma, glioma, and prostate. For the other cancer sites, results from only one study were available for evaluation.

5.2.1 NHL and other haematopoietic cancers

Two large case–control studies of NHL from Canada and the USA, and two case–control studies from Sweden reported statistically significant increased risks of NHL in association with exposure to glyphosate. For the study in Canada, the association was seen among those with more than 2 days/year of exposure, but no adjustment for other pesticides was done. The other three studies reported excesses for NHL associated with exposure to glyphosate, after adjustment for other pesticides (reported odds ratio were 2.1 (95% CI, 1.1–4.0); 1.85 (95% CI, 0.55–6.2); and 1.51 (95% CI, 0.77–2.94). Subtype-specific analyses in a Swedish case–control study indicated positive associations for total NHL, as well as all subtypes, but this association was statistically significant only for the subgroup of lymphocytic lymphoma/chronic lymphocytic leukaemia (OR, 3.35; 95% CI, 1.42–7.89). An elevated risk (OR, 3.1; 95% CI, 0.6–17.1) was also found for B-cell lymphoma in an European study based on few cases. One hospital-based case–control study from France did not find an association between exposure to glyphosate and NHL (OR, 1.0; 95% CI, 0.5–2.2) based on few exposed cases.

A roughly twofold excess of multiple myeloma, a subtype of NHL, was reported in three studies: only among the highest category of glyphosate use (> 2 days/year) in the large Canadian case–control study, in a case–control study from Iowa, USA, and in a French case–control study (all not statistically significant). These three studies did not adjust for the effect of other pesticides. In the AHS, there was no association with NHL (OR, 1.1; 0.7–1.9). For multiple myeloma, relative risk was 1.1 (95% CI, 0.5–2.4) when adjusted for age only; but was 2.6 (95% CI, 0.7–9.4) when adjusted for multiple confounders. No excess in leukaemia was observed in a case–control study in Iowa and Minnesota, USA, or in the AHS.

In summary, case–control studies in the USA, Canada, and Sweden reported increased risks for NHL associated with exposure to glyphosate. The increased risk persisted in the studies that adjusted for exposure to other pesticides. The AHS cohort did not show an excess of NHL. The Working Group noted that there were excesses reported for multiple myeloma in three studies; however, they did not weight this evidence as strongly as that of NHL because of the possibility that chance could not be excluded; none of the

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risk estimates were statistically significant nor were they adjusted for other pesticide exposures.

5.2.2. Other cancer sites

No association of glyphosate with cancer of the brain in adults was found in the Upper Midwest Health case–control study. No associations in single case–control studies were found for cancers of the oesophagus and stomach, prostate, and soft-tissue sarcoma. For all other cancer sites (lung, oral cavity, colorectal, pancreas, kidney, bladder, breast, prostate, melanoma) investigated in the large AHS, no association with exposure to glyphosate was found.

5.3 Animal carcinogenicity data

Glyphosate was tested for carcinogenicity in male and female mice by dietary administration in two studies, and in male and female rats by dietary administration in five studies and in drinking-water in one study. A glyphosate-based formulation was also tested in drinking-water in one study in male and female rats, and by skin application in one initiation–promotion study in male mice.

There was a positive trend in the incidence of renal tubule carcinoma and of renal tubule adenoma or carcinoma (combined) in males in one feeding study in CD-1 mice. Renal tubule carcinoma is a rare tumour in this strain of mice. No significant increase in tumour incidence was seen in female mice in this study. In the second feeding study, there was a significant positive trend in the incidence of haemangiosarcoma in male CD-1 mice. No significant increase in tumour incidence was seen in female mice in this study.

For the five feeding studies in rats, two studies in the Sprague-Dawley strain showed a significant increase in the incidence of pancreatic islet cell adenoma in males – one of these two studies also showed a significant positive trend in the incidences of hepatocellular adenoma in males and of thyroid C-cell adenoma in females. Two studies (one in Sprague-Dawley rats, one in Wistar rats) found no significant increase in tumour incidence at any site. One study in Wistar rats was inadequate for the evaluation because of the short duration of exposure.

In the study in Wistar rats given drinking-water containing glyphosate, there was no significant increase in tumour incidence.

A glyphosate-based formulation was found to be a skin-tumour promoter in the initiation–promotion study in male Swiss mice. The study of a glyphosate-based formulation in drinking-water in Sprague-Dawley rats was inadequate for the evaluation because of the small number of animals per group, and the limited information provided on tumour histopathology and incidence in individual animals. These studies of a chemical mixture containing glyphosate were considered inadequate to evaluate the carcinogenicity of glyphosate alone.

5.4. Other relevant data

Direct data on absorption of glyphosate in humans were not available to the Working Group. Glyphosate was detected in the urine of agricultural workers in several studies, and in the blood of poisoning cases, indicative of absorption. Some evidence for absorption through human skin (~2%) was reported in studies in vitro. The minor role of dermal absorption was also shown in a study in non-human primate model in vivo. However, no study examined the rates of absorption in humans. In rodents, several studies showed up to 40% absorption after oral administration of a single or repeated dose.

Glyphosate was measured in human blood. No data on parenchymal tissue distribution for glyphosate in humans were available to the Working Group. In rats given glyphosate by oral administration, concentrations in tissues had the following rank order: kidneys > spleen > fat > liver. Repeated administration had no effect

on the distribution of glyphosate. In a study in rats, the half-life of glyphosate in plasma was estimated to be more than 1 day, indicating that glyphosate is not rapidly eliminated.

In the environment, glyphosate is degraded by soil microbes, primarily to aminomethylphosphonic acid (AMPA) and carbon dioxide. Glyphosate is not efficiently metabolized in humans or other mammals. In rats, small amounts of AMPA were detected in the plasma and in the colon, with the latter being attributed to intestinal microbial metabolism. In humans, small amounts of AMPA are detectable in blood in cases of deliberate glyphosate poisoning. Few studies examined the possible effects of glyphosate-based formulations on metabolizing enzymes, but no firm conclusions could be drawn from these studies.

Studies in rodents showed that systemically absorbed glyphosate is excreted unchanged into the urine, and that the greatest amount is excreted in the faeces, indicating poor absorption. Glyphosate was detected in the urine of humans who were exposed occupationally to glyphosate. AMPA has also been detected in human urine.

Glyphosate is not electrophilic.

A large number of studies examined a wide range of end-points relevant to genotoxicity with glyphosate alone, glyphosate-based formulations, and AMPA.

There is strong evidence that glyphosate causes genotoxicity. The evidence base includes studies that gave largely positive results in human cells in vitro, in mammalian model systems in vivo and in vitro, and studies in other non-mammalian organisms. In-vivo studies in mammals gave generally positive results in the liver, with mixed results for the kidney and bone marrow. The end-points that have been evaluated in these studies comprise biomarkers of DNA adducts and various types of chromosomal damage. Tests in bacterial assays gave consistently negative results.

The evidence for genotoxicity caused by glyphosate-based formulations is strong. There were three studies of genotoxicity end-points in community residents exposed to glyphosate-based formulations, two of which reported positive associations. One of these studies examined chromosomal damage (micronucleus formation) in circulating blood cells before and after aerial spraying with glyphosate-based formulations and found a significant increase in micronucleus formation after exposure in three out of four different geographical areas. Additional evidence came from studies that gave largely positive results in human cells in vitro, in mammalian model systems in vivo and in vitro, and studies in other non-mammalian organisms. The end-points that were evaluated in these studies comprised biomarkers of DNA adducts and various types of chromosomal damage. The pattern of tissue specificity of genotoxicity end-points observed with glyphosate-based formulations is similar to that observed with glyphosate alone. Tests in bacterial assays gave generally negative results.

For AMPA, the evidence for genotoxicity is moderate. While the number of studies that examined the effects of AMPA was not large, all of the studies gave positive results. Specifically, genotoxicity was reported in a study in humans in vitro, a study in mammals in vivo, a study in mammals in vitro, and one study in eels in vivo.

Strong evidence exists that glyphosate, AMPA, and glyphosate-based formulations can induce oxidative stress. Evidence came from studies in many rodent tissues in vivo, and human cells in vitro. In some of these studies, the mechanism was challenged by co-administration of antioxidants and observed amelioration of the effects. Similar findings have been reported in fish and other aquatic species. Various end-points (e.g. lipid peroxidation markers, oxidative DNA adducts, dysregulation of antioxidant enzymes) have been evaluated in numerous studies. This

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increased the confidence of the Working Group in the overall database.

There is weak evidence that glyphosate or glyphosate-based formulations induce receptor-mediated effects. In multiple experiments, glyphosate-based formulations affected aromatase activity; glyphosate was active in a few of these studies. Some activity in other nuclear receptor-mediated pathways has been observed for glyphosate or glyphosate-based formulations. In one series of experiments, glyphosate was not found to be a ligand to several receptors and related proteins (aryl hydrocarbon receptor, peroxisome proliferator-activated receptors, pregnane X receptor).

There is weak evidence that glyphosate may affect cell proliferation or death. Several studies in human and rodent cell lines have reported cytotoxicity and cell death, the latter attributed to the apoptosis pathway. Studies that examined the effects of glyphosate alone or a glyphosate-based formulation found that glyphosate alone had no effect, or a weaker effect than the formulation.

There is weak evidence that glyphosate may affect the immune system, both the humoral and cellular response, upon long-term treatment in rodents. Several studies in fish, with glyphosate or its formulations, also reported immunosuppressive effects.

With regard to the other key characteristics of human carcinogens (IARC, 2014), the Working Group considered that the data were too few for an evaluation to be made.

Severe or fatal human poisoning cases have been documented worldwide. In rodents, organ and systemic toxicity from exposures to glyphosate are demonstrated by liver-weight effects and necrosis in animals at high doses. Additionally, effects on the pancreas, testes, kidney and ovaries, as well as reduced implantations and unossified sternebra were seen at similar doses.

No data on cancer-related susceptibility after exposure to glyphosate were available to the Working Group.

Overall, the mechanistic data provide strong evidence for genotoxicity and oxidative stress. There is evidence that these effects can operate in humans.

6. Evaluation

6.1 Cancer in humans

There is *limited evidence* in humans for the carcinogenicity of glyphosate. A positive association has been observed for non-Hodgkin lymphoma.

6.2 Cancer in experimental animals

There is *sufficient evidence* in experimental animals for the carcinogenicity of glyphosate.

6.3 Overall evaluation

Glyphosate is *probably carcinogenic to humans (Group 2A).*

6.4 Rationale

In making this overall evaluation, the Working Group noted that the mechanistic and other relevant data support the classification of glyphosate in Group 2A.

In addition to limited evidence for the carcinogenicity of glyphosate in humans and sufficient evidence for the carcinogenicity of glyphosate in experimental animals, there is strong evidence that glyphosate can operate through two key characteristics of known human carcinogens, and that these can be operative in humans. Specifically:

- There is strong evidence that exposure to glyphosate or glyphosate-based formulations is genotoxic based on studies in humans in vitro and studies in experimental animals.

One study in several communities in individuals exposed to glyphosate-based formulations also found chromosomal damage in blood cells; in this study, markers of chromosomal damage (micronucleus formation) were significantly greater after exposure than before exposure in the same individuals.

- There is strong evidence that glyphosate, glyphosate-based formulations, and aminomethylphosphonic acid can act to induce oxidative stress based on studies in experimental animals, and in studies in humans in vitro. This mechanism has been challenged experimentally by administering antioxidants, which abrogated the effects of glyphosate on oxidative stress. Studies in aquatic species provide additional evidence for glyphosate-induced oxidative stress.

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Comment Letter I-Fra3 Fraser, Mary

Response 1

Comment noted on the commenter's displeasure with the time for review and the provision of CDs to 29 public libraries. Ms. Fraser's request for extension of time to 120 days was not granted. Two requests for limited extensions of review time were granted to NMWD for receipt of comments on October 6, 2015, and to CDFW for receipt of comments on October 19, 2015. The California Department of Parks and Recreation missed the comment deadline by 14 days, and the District decided to include their brief comments into the PEIR, The NOA stated that the PEIR was available on the District's website, so the public could access the document from their homes. Ms. Fraser was also given a CD at the public hearing on September 15. A hard copy of the entire document was available at District offices for review by appointment to facilitate its review by anyone who did not have access to a computer.

The distribution and availability of the Draft PEIR follows CEQA requirements and common practices of providing appropriate opportunities for public review and comment. The standard 45-day review period was extended by 5 days to allow for additional review time by interested parties on the District's mailing list (356 addresses). Each hard copy cost approximately $500 to produce, and the District is not obligated to provide hard copies without charge. The District is also not required to place large, expensive display advertisements in the newspapers. Only the legal notices are required along with posting of the NOA at the County Clerks' offices. The District's mailing list was originally developed by the Marin County Planning Department for use in notifying the public of the availability of CEQA documents. It included 81 nongovernmental organizations and special interest groups/associations.

Although Ms. Fraser states she has not had time to adequately review the entire PEIR, she did provide seven separate written comments, participated in the group represented by the Law Offices of Stephan C. Volker, and provided oral comments at two of the three public hearings.

The PEIR was organized to have specific chapters on ecological health (Chapter 6) and on human health (Chapter 7) to help those who were only interested in these two subjects to focus quickly. Chapter 1 listed the environmental topics and concerns covered under each chapter (Section 1.5 Environmental Concerns). Most PEIR reviewers only read the Summary followed by Chapters 1 and 2 and the specific resource chapters of concern to them. Very few people read an entire EIR (any EIR) cover to cover.

Response 2

Concerning the comment on the public hearing presentation, the District uses several biorational formulations of mosquito larvicides that contain three bacterial active ingredients that are found in nature. Certain formulations containing these active ingredients are labeled for use with organic crops by the Organic Materials Review Institute and the USEPA. Examples of bacteria pathogenic to mosquitoes are *Bacillus sphaericus* (Bs), the several strains of *Bacillus thuringiensis israelensis* (Bti), and *Saccharopolyspora spinosa*. Two bacteria, Bs and Bti, produce proteins that are toxic to most mosquito larvae, while *Saccharopolyspora spinosa* produces compounds known as spinosyns, which effectively control all larval mosquitoes. Bs can reproduce in natural settings for some time following release. The Bti materials the District applies do not contain live organisms but only spores made up of specific protein molecules. All three bacteria are naturally occurring soil organisms that are also commercially produced for use as mosquito larvicides. These are the only three active ingredients approved for use in controlling larval mosquitoes when organic production is in progress.

None of the other natural or synthetic materials involved in vector control were cited in the presentation as being consistent with organic farming. Glyphosate is a synthetic chemical and is not approved for use on organic farms. The PEIR preparers reviewed numerous studies on glyphosate, the WHO report, and scientific reviews of the World Health Organization (WHO) report in determining that potential use by the

District poses a less-than-significant impact on human health. The WHO report is the result of a "panel discussion and vote" by the International Agency for Research on Cancer (IARC) about the potential for selected chemicals and products that have achieved some level of public interest and concern but may or may not be supported by the data and information available. The panel is comprised of several European scientists and government organizations reporting to the WHO (a scientifically conservative advocacy agency) sponsored by the UN. This group is known to generally follow the "precautionary principle" that is used by some members of the public to argue against chemical use. The precautionary principle is a hypothesis generally rejected by the scientific community that "unless one can prove there is or can be no adverse impacts of a substance it should be considered hazardous." To those with scientific training, this suggests that one must "prove a negative" which is essentially impossible in any statistical sense of a scientific study.

In fact, the IARC has been challenged by dozens of technical experts who evaluated the process used by the panel to list glyphosate as a probable carcinogen. It has been demonstrated that IARC rejected the 800 studies / 3,000 documents that gave glyphosate a positive safety result, basing their decision of "probably carcinogenic" on only eight studies, of which three actually included results that were themselves arguably insignificant. After the WHO publication listing glyphosate as a probable carcinogen, dozens of practicing scientists in the mainstream scientific community (including European Food Safety Administration, the German Federal Institute for Risk Assessment (*BfR*) and the lead author of one of the studies used by IARC to draw their conclusions) have criticized and disputed the results of the IARC for using a poor methodology and inadequate research. The conclusions drawn by the IARC about the potential adverse effects of glyphosate were based on studies that are not relevant to actual, potential exposures and on studies that were based on high exposures to petri dish cells and in vitro laboratory conditions.

Glyphosate exposure was not associated with cancer incidence overall or with most of the cancer subtypes studied by de Roos et al (2005). Given the widespread use of glyphosate, and the paucity of information indicating significant and relevant causality, the nonscientific claims that glyphosate exhibits numerous low-level or sublethal adverse effects (Seneff nd.) are insufficient to refute the weight of the evidence that the District's use of glyphosate would not have significant impacts. Relevant to this conclusion is the fact that many of the publications cited as demonstrating adverse impacts from glyphosate, particularly those suggesting sublethal adverse effects of glyphosate by Seneff et al, have been discounted and the reports retracted after pressure from the active research community. The reports submitted by Seneff and many of her co-authors have been retracted due to pressure from editorial boards and practicing scientists. Some of the reports she has submitted incorrectly and unscientifically relate correlation to causality. This method produces two general statements, for example, that cannot be linked statistically or even practically. She has been ostracized for this approach, and some of her papers have had to be retracted. An example of this un-scientific comparison is to relate national health data with national pesticide use and suggest that they are clearly linked, while, in fact, there is no connection to actual exposures. For example, the following study had to be retracted after pressure from the editors: One of the papers that was critically reviewed and retracted is "Long term toxicity of a Roundup herbicide and a Roundup-tolerant genetically modified maize" (Séralini et al. 2012).

To be retracted in science journals is a harsh critique of a submitted work and means that the editorial board and a number of recognized scientists in the field have demonstrated a fatal or a series of fatal flaws in the logic, assumptions, and conclusions. Seneff is a computer modeler who uses meta-analysis techniques and not a practicing researcher. She fails to evaluate the risk/benefit analyses that are utilized by USEPA and other regulators. The District's PEIR scientists have reviewed each of the seven articles submitted directly by Ms. Fraser.

The senior toxicologist on the consultant team who prepared the District's PEIR, Dr. Bill Williams, concluded that there have been no demonstrated significant adverse health effects (even for pesticide applicators). The studies reporting potential human health effects are associated with extreme exposures

to applicators during misuse scenarios and spills and/or working in the preparation of the commercial products (Mink et al. 2012). These conditions and potential exposure conditions are neither typical nor likely in the use and applications by trained District staff. All application directions include detailed procedures to deal with a spill. Glyphosate remains a reliable and environmentally compatible product for use in the numerous situations where control of vegetation is needed for habitat management (for vector control or for invasive species control). Importantly, it has been demonstrated that herbicides are a different class of chemicals than those classified as insecticides that have specific, demonstrated autonomic effects. The media reports about the hazards of glyphosate and its several commercial products have not been clearly associated with human health. The numerous reports about "possible" connections to metabolic processes and subtle effects also include confounding factors that make scientifically defensible claims impossible. Where there are reports of adverse subtle effects, they are usually based on laboratory studies of changes to cells after immersion exposures, which are exposures far above any possible actual human (or animal) exposure. The implication and correlation of such exposures to actual potential exposures in humans or animals are not realistic.

USEPA continually reviews the available scientific data and other relevant information in support of the registration of glyphosate (i.e., commercial product Roundup for weed control) and has indicated that there are sufficient data to assess the hazards of and to make a determination on aggregate exposure for glyphosate including exposure resulting from the tolerances established by this action. USEPA's assessment of exposures and risks associated with glyphosate are clearly indicated in the numerous studies used to develop the guidance for use. Using these data, the USEPA has set maximum safe exposure levels for both humans and animals (tolerances) of pesticide residues for crops based on the huge number of scientific studies and complex risk assessment approaches provided in support of the active ingredient in the products. These tolerances are hundreds of times higher than estimated toxic values using total exposure values to pesticides (including safety levels to protect children and others who may be vulnerable). The USDA tests crops each year to make sure they do not exceed the tolerances. Very few pesticides are found above the tolerance levels (despite some unsubstantiated media reports). The exposures that were used in the WHO evaluation and studies were not reasonable examples of the exposures that might be encountered by humans. US Environmental Protection Agency (USEPA) 1993 and National Pesticide Information Center, Oregon State University 2011. There are occasionally media reports of studies linking glyphosate to cancers of various types, but these are generally results from cultured cells in the laboratory. Extrapolation of these very high dose laboratory studies to animals and humans are not reliable indicators of potential adverse effects from the Program use, because they would require direct exposure or even ingestion, neither of which is reasonably foreseeable under the Program. See Response O-VOL-22.

Response 3

The commenter suggests that the PEIR's information on glyphosate is inaccurate and relies on old information. The fact that a study was done in 1993 does not make it invalid. Moreover, the body of information for the registration of glyphosate has been submitted to the USEPA in dozens of studies, first by the manufacturer and its university and contractor scientists. The suite of studies required for approval include dozens and dozens of potential acute and chronic tests to detect possible effects to mammals (as surrogates for humans as well as for wildlife), birds, invertebrates, and bees. The research test data submitted to the USEPA is an ongoing process required for its Re-registration Eligibility Decision (RED) in which label changes and use patterns are reviewed and updated. See also Response 2 above on EPA continual reviews of the available studies.

The links considered in this comment are to the following studies:

> Mesnage et al., 2014, Major pesticides are more toxic to human cells than their declared active principles, BioMed Res International Volume 2014

> Mesnage et al, 2012, Ethoxylated adjuvants of glyphosate-based herbicides are active principles of human cell toxicity,*Toxicology* 313 (2-3) 2013

> Samsel and Seneff, 2015, Glyphosate, pathways to modern diseases III: Manganese, neurological diseases, and associated pathologies, *Surg Neurol Int* 6

> Stephanie Seneff Home Page with selected abstracts and references of 25

These studies are addressed above in Response 2 and do not result in a change to any of the conclusions reached in the PEIR.

Response 4

The commenter is concerned about other ingredients combined with glyphosate that enhance the toxicity of glyphosate. Ms. Fraser cites the following studies: Mesnage et al (2014) and selected abstracts in PowerPoint from her Home Page (Seneff at Mit).

There are numerous pesticide products that include inert and/or chemically different additives to enhance the spray characteristics, adhesion properties, and efficacy. Many of those products have been specially tested for toxicity and registered with the USEPA for specific vector control purposes (National Park Service 2016). Although some of these mixture products have been associated with increased toxicity, numerous studies have demonstrated that the increase in toxicity may be due to a surfactant additive. In most instances, these special formulations of pesticide products are intended to reduce the potential for adverse effects or to specifically be used for aquatic environments, e.g. a glyphosate product, Accord, which has been shown to be safer to aquatic wildlife than some of the other formulations of glyphosate (Brodman et al. 2010).

All chemicals can cause adverse effects or even become be toxic at levels exceeding individual species “tolerance” levels. However, the sensitivity and tolerance levels are determined by the USEPA and other regulatory agencies using laboratory tests with numerous species of concern that are estimated to be potentially exposed to an application. The results of these tests on each chemical are published in numerous publically available USEPA documents summarizing the testing results with metrics such as the LD50, LC50 and maximum estimated tolerance levels. For the pesticides used by the District for vector control, these metrics are indicated in detail in Appendix B of the PEIR, with information on a current species of interest (honeybee).

Studies submitted to, reviewed by, and accepted by the USEPA scientists in support of the registration of glyphosate indicate that both technical and formulated glyphosate are practically nontoxic to honeybees with a contact LD50 value greater than 100 µg/bee applied directly to the thorax with a saturated Q-tip (Frasier and Jenkins 1972, the contract scientists for the manufacturer, who submitted the studies for inclusion in the toxicity evaluation). This technique, designed to simulate a worst case exposure to the bee, results in considerably greater exposure than likely under natural conditions in the environment where applications could occur. Over the past decades, to update and support the original data submitted by Frasier and Jenkins, several studies on glyphosate have been conducted to confirm and validate the toxicity estimates first submitted to USEPA for registration. These studies have been submitted to the USEPA for inclusion in the Integrated Risk Information System (IRIS, USEPA). The recent data submissions and reports continue to support the finding that glyphosate is “relatively” nontoxic to honey bees (Porterfield 2015; Zhu et al. 2015; Giesy et al. 2000; see also Table 6-1 in Appendix B of the PEIR).

While it has been reported that the addition of some surfactants to the base chemical glyphosate may make the products more toxic to some biota, the primary concern is toxicity based on studies using high, continuous exposures in laboratory tests. The exposures in the laboratory studies are clearly not representative to realistic field conditions or exposures in field applications because the laboratory studies involve captive test species, unable to choose uncontaminated food or habitat. Many laboratory tests are designed and conducted to determine the ‘worst-case” exposure to a chemical and then to lower the test

concentrations slowly until a test concentration shows no adverse effect to the test animals (USEPA 2012; Williams et al. 1994). In this way, the concentrations that produce exposures with little or no adverse response can be documented and used to define the applications that should not be hazardous to the animals and environment. As in all relevant laboratory toxicity studies, the exposures in laboratory conditions are essentially 100 percent with no ability to choose areas of lessor concentrations, and use non-representative exposures. The best available evidence indicates that glyphosate toxicity would not occur as a result of the District's method of use of the chemical under the Program.

See also Response O-VOL-17.

Response 5

The commenter is referring to Section 4.6.2.3 in Appendix B which was prepared in June 2013. Since then, additional studies have been reviewed including the WHO report, which was published in 2015. The WHO report is the result of a "panel discussion" by the International Agency for Research on Cancer (IARC) about the potential for selected chemicals and products that have achieved some level of public interest and concern but may or may not be supported by the data and information available. In fact, the IARC has been challenged by dozens of technical experts who evaluated the process used by the panel to list glyphosate as a probable carcinogen. It has been demonstrated that IARC rejected the 800 studies / 3,000 documents that gave glyphosate a positive safety result, basing their decision of "probably carcinogenic" on only eight studies, of which three actually included results, which results were arguably insignificant. See Response 2 above.

The commenter suggested that glyphosate degrades slowly and is not subject to biodegration. The product Roundup (glyphosate active ingredient) is degraded over time by soil microbes into breakdown products and naturally-occurring substances. Giesy et al. (2000) in field studies concluded the following: "Field studies indicate that glyphosate typically dissipates rapidly from both simple ecosystems, such as agricultural, and more complex ecosystems, such as forestry, regardless of the diverse edaphic [soil] and climatic conditions." The authors also concluded that field studies conducted in agricultural and forest soils (13 studies, five countries, 47 different sites) indicated an average half-life of 32 days. In 2002, the European Commission completed an assessment of fate and behavior of glyphosate in environment (European Commission 2002). Under a wide range of climatic conditions found in the US, Canada, and Europe, the mean half- life for glyphosate degradation in field soil was reported to be 30 days, with a range from 1 to 130 days, while the half-life of glyphosate (the time required for half of the compound to dissipate or degrade) varies, depending on conditions. The variability in rates of glyphosate degradation is believed to be due to the varying microbial activity and extent of soil-binding at the different study sites (Giesy et al. 2000).

The comment on the lawsuit against Monsanto for false advertising is not relevant to the PEIR discussion on glyphosate products for vegetation management as part of the District's IVMP. No further response is required.

Response 6

The attachments provided by the commenter by email are provided following her comment include the following seven studies:

> Anthony Samsel and Stephanie Seneff, Glyphosate's Suppression of Cytochrome P450 Enzymes and Amino Acid Biosynthesis by the Gut Microbiome: Pathways to Modern Diseases (Samsel and Seneff 2013a)

> Anthony Samsel and Stephanie Seneff. Glyphosate, pathways to modern diseases II: Celiac sprue and gluten intolerance (Samsel and Seneff 2013b)

> Anthony Samsel and Stephanie Seneff. Glyphosate, pathways to modern diseases III: Manganese, neurological diseases, and associated pathologies (Samsel and Seneff 2015)

> Judy Hoy, Nancy Swanson, and Stephanie Seneff. The High Cost of Pesticides: Human and Animal Diseases (Hoy et al. 2015)

> Chen I-wan, Glyphosate, Roundup, Glyphosate-Tolerance GM Soybeans, Chemical Extracted Soybean Food Oil/Soybean Powder Cause Serious Harm to Health of American/Chinese People. Reference Information (Chen I-wan 2014)

> Robin Mesnage, Nicolas Defarge, Joël Spiroux de Vendômois, and Gilles-Eric Séralini. Major Pesticides Are More Toxic to Human Cells Than Their Declared Active Principles (Mesnage et al. 2014)

> R. Mesnagea, B. Bernayc, G. E. Séralini. Ethoxylated adjuvants of glyphosate-based herbicides are active principles of human cell toxicity (Mesnage et al. 2012)

These studies provided by Mary Frasier have been reviewed for their content and applicability to exposure to glyphosate and ethoxylated adjuvants that may be correlated with diseases and health. They are addressed and considered for the Final PEIR as follows:

> All three Samsel et al, publications (2013a, 2013b, and 2015) are discussions of the possible impacts of glyphosate on metabolic and gastric functions, even gluten intolerance. Although there are extensive illustrations and graphics, the relation between the diseases listed and actual pesticide exposures are not conclusive. The papers read like monographs covering dozens of potential adverse impacts of glyphosate. One of the co-authors (Seneff) has had issues with the credibility of the assumptions and conclusions in her papers, and these papers do not clearly equate the linkages to metabolic impacts. The conclusions made cannot be easily evaluated or supported as the illustrations all present summary data from other sources. The presentations are not relevant to the PEIR as presented.

> Hoy et al. (2015) discusses the linkage of human and wildlife health and pesticide use in Montana, suggesting a relationship to glyphosate. The focus on diseases at the state level vs pesticide uses at the state level does not provide an adequate link to a causal correlation. The presentations are not relevant to the PEIR as presented.

> Mesnagea et al. (2012 and 2014), both discuss possible linkage of glyphosate products and ethoxylated adjuvants in the onset of sublethal or chronic adverse effects. They provide information on all three classes of pesticides: herbicides, fungicides, and insecticides. The papers contain summaries of possible impacts of these pesticides and focus on the formulations rather than the active ingredient of each pesticide. The information is interesting and organized, but the information is not specific or relevant to the PEIR.

> Chen I-wan (2014) is an extensive discussion of cancer incidence in several areas of China that the author suggests are linked to food products. He provides extensive and comprehensive details of the demographics of cancer incidence in China. The report provides a level of information generally attributed to a monograph about the cancers in China. The information is interesting and impressive, but the information is not relevant to the PEIR.

Response 7

The commenter asks that glyphosate not be used and that no chemicals be used; she supports the No Chemical Program. This comment will be considered by the District's Board of Trustees in its consideration whether to approve the Program as proposed, or with modifications.

Additional References

Brodman, R., W.D. Newman, K. Laurie, S. Osterfeld, and N. Lenzo. 2010. Interaction of an aquatic herbicide and predatory salamander density on wetland communities. Journal of Herpetology 44(1):69-82

Chen, I-wan. 2014. Glyphosate, Roundup, Glyphosate-Tolerance GM Soybeans, Chemical Extracted Soybean Food Oil/Soybean Powder Cause Serious Harm to Health of American/Chinese People. Reference Information. June 18.

De Roos, A.J., A. Blair, J.A. Rusiecki, J.A. Hoppin, M. Svec, M. Dosemeci, D.P. Sandler, and M.C. Alavanja. 2005. Cancer incidence among glyphosate-exposed pesticide applicators in the Agricultural Health Study. Environmental Health Perspectives 113 (1): 49–54. January.

European Commission. 2002. Report for the Active Substance Glyphosate, Directive 6511/VI/99, January 21. Available online at http://europa.eu.int/comm/food/fs/ph_ps/pro/eva/existing/list1_glyphosate_en.pdf.

Frasier, W.D., G. Jenkins. 1972. The acute contact and oral toxicities of CP67573 and MON2139 to worker honey bees. Report 4G1444 submitted to US Environmental Protection Agency by Monsanto Company and prepared by Huntingdon Research.

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Porterfield, A, 2015. Study finds glyphosate and acetamiprid to have relative low toxicity for honey bees. Entomology Today, October 13,

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Samsel, A., and S. Seneff. 2013a. Glyphosate's suppression of cytochrome P450 enzymes and amino acid biosynthesis by the gut microbiome: pathways to modern diseases. Entropy 15: 1416-1463.

Samsel, A., and S. Seneff. 2013b. Glyphosate, pathways to modern diseases II: celiac sprue and gluten intolerance. Interdisciplinary Toxicology 6(4): 159–184.

Samsel, A., and S. Seneff. 2015. Glyphosate, pathways to modern diseases III: Manganese, neurological diseases, and associated pathologies. Surg Neurol Int 6:45.

US Environmental Protection Agency (USEPA). 2012. Test Guidelines for Pesticides and Toxic Substances. Series 850 under FIFRA, TSCA, and FFDCA. June. Available online at http://www.epa.gov/test-guidelines-pesticides-and-toxic-substances/series-850-ecological-effects-test-guidelines

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I-Fra4

Comment 4 from Mary Fraser

Dear District Board of Directors and Staff,
I urge you to choose the No Chemical option from the Draft PEIR. Many other places are understanding how detrimental to the environment and human health the use of pesticides are. Attached is a list of many other places that have either banned or restricted pesticides. Here is the text of a speech that I gave about the other places that have banned pesticides and their reasons for doing so.

1

Board of Supervisors and Ladies and Gentlemen,

My name is Mary Fraser. I am a resident of Marin Co.

I am here today to urge you to ban pesticides in Marin County. Today I want to talk about other places that have banned pesticides and why they chose to do so. Each place is a little different but they all chose public health over the use of pesticides.

As you may know, the Marin Municipal Water District recently chose to exclude the use of pesticides from the 26,000 acres they manage. This is a continuation of a 9 yr. hiatus in the use of pesticides. No one wants pesticides in our water supply.

2

Richmond CA has banned pesticides. This effort was led by 2 doctors, one of whom is the retired chief of cardiology for Kaiser Permanente. Dr. Jeff Ritterman wrote and published an extensive article outlining the public health reasons for banning pesticides. I had the privilege to hear Dr. Ritterman speak recently. He started his talk by saying that the compelling evidence against pesticide use was the birth defects that are showing up in South America. We are talking about babies born with no skull. Babies born with no arms AND no legs. Babies born with one big cyclops eye. Defects nearly identical to the ones that happened in VietNam after we defoliated the country with Agent Orange. And we did not ban the entire formula of Agent Orange. Only 2, 4 T. We still use 2, 4 D on our agriculture.

So in Argentina, because of the health consequences, 30,000 doctors have called for a ban on pesticides. 30,000 doctors.

In El Salvador, 20,000 men have died in the last 5 years because they started using pesticides in the sugar cane fields. In El Salvador they've banned 32 different pesticides.

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Sri Lanka has the same issue. Thousands are dying from kidney disease. One of the reasons that they have such terrible kidney diseases is because they have serpentine soil. We have serpentine soil in Marin. Sri Lanka has banned pesticides.

France has banned them. The Netherlands has banned non commercial use. German ministers are calling for a ban in the entire European Union. All of these countries operate on the precautionary principle, where chemicals have to be proven safe before they can be used. In America, we have the opposite policy. Chemicals undergo minimal testing by the manufacturer and then the public has to prove that a chemical is unsafe before it can be forced off of the market. This can take decades and have untold consequences.

2

So I'm asking the Board of Supervisors to be our heroes and ban pesticides on all of the property that the County of Marin owns, leases and manages, including Open Space.

Places where the use of glyphosate and/or pesticides are restricted or banned.

Marin County:

Marin Municipal Water District, Marin County, CA. 22,000 acres of watershed- Pesticides banned. Vote taken 7/7/15 http://www.marinij.com/environment-and-nature/20150708/marin-water-district-herbicides-wont-be-used-on-mount-tam

City of Fairfax, CA- Pesticides banned on commons.

City of Belvedere, CA- Pesticides banned on commons.

City of Sausalito, CA-Pesticides under review

Reed School District, Tiburon, CA- Pesticides not used on school district grounds.

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Larkspur-Corte Madera School District, Corte Madera, CA-Pesticides not used on school grounds.

Mill Valley School District, Mill Valley, CA- Pesticides not used on school grounds.

States:

Connecticut: Pesticides banned on municipal playgrounds:

http://www.beyondpesticides.org/dailynewsblog/2015/07/connecticut-bans-toxic-lawn-pesticides-in-municipal-playgrounds-statewide

New York: Pesticides banned on school grounds

-

Countries:

Country of the Netherlands- Glyphosate banned for non-commercial use.
http://sustainablepulse.com/2014/04/04/dutch-parliament-bans-glyphosate-herbicides-non-commercial-use/#.VZ2Wca5Vikp

Country of Sri Lanka-Glyphosate banned
http://www.publicintegrity.org/2014/03/13/14418/sri-lanka-bans-monsanto-herbicide-citing-potential-link-deadly-kidney-disease.

County of El Salvador- Glyphosate banned by legislature.

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Country of Bermuda- Glyphosate imports suspended.
http://www.todayinbermuda.com/news/health/item/1471-health-minister-importation-of-roundup-weed-spray-suspended

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Country of Brazil. Chief prosecutor wants glyphosate banned.
http://www.globalresearch.ca/brazils-public-prosecutor-wants-to-ban-monsantos-chemicals-following-recent-glyphosate-cancer-link/5449440

Country of Germany and the European Union (EU). EU ban proposed by ministers.
http://www.globalresearch.ca/german-ministers-call-for-eu-wide-ban-on-monsantos-deadly-glyphosate-herbicide-roundup/5451831

1. Country of Argentina. 30,000 medical doctors call for ban on glyphosate.
   http://www.globalresearch.ca/30000-doctors-in-argentina-demand-that-glyphosate-be-banned/5445542

   -

   Country of Columbia. Glyphosate banned for use on illicit crops.
   http://www.bbc.com/news/world-latin-america-32677411

   -

   Country of France. Sale of glyphosate banned.
   http://www.naturalnews.com/050248_french_legislation_glyphosate_ban_Monsanto_GMOs.html

   -

   States:

   Connecticut: Pesticides banned on municipal playgrounds:

http://www.beyondpesticides.org/dailynewsblog/2015/07/connecticut-bans-toxic-lawn-pesticides-in-municipal-playgrounds-statewide

New York: Pesticides banned on school grounds

I-Fra4

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Cities:

City of Richmond, CA- Moratorium on organophosphate pesticides

Chicago, IL,

Takoma Park, MD

Laguna Hills, CA

Durham, CT

Paris, France

University of Vermont Law School and Emory University campuses have banned all pesticides

Santa Barbara, CA

Carrboro, NC

Plainville, CT

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Santa Fe, NM

The township of Marblehead, Massachusetts instituted one of the earliest ordinances calling for the use of Organic Land Care on township lands and has successfully implemented fully organic techniques for turf management.

Between 1996 and 2005 San Francisco municipal agencies achieved an 85% reduction in gallons of liquid pesticide, a 55% decrease in pounds of solid pesticides, and a 90% decrease in the use of Roundup®, one of the herbicides most widely used by municipalities. San Francisco has been so successful that in 2005 New York City passed a similar local law based largely on San Francisco's ordinance.

Mary Fraser
[redacted]

Comment Letter I-Fra4 — Fraser, Mary

Response 1

The commenter asks that no chemicals be used; she supports the No Chemical Program. This comment will be considered by the District's Board of Trustees in its consideration whether to approve the Program as proposed, or with modifications.

Response 2

The commenter provides a speech to the Marin County Board of Supervisors that is against the use of various pesticides followed by lists of places where glyphosate or other pesticides are restricted.

The Draft PEIR listed the communities in the Program Area that had adopted IPM policies or restrictions on pesticide use in Section 3.1.3.3. Several of these local policies and ordinances are applicable only to government (city-owned) property and have exceptions for protection of public health. As stated in this section:

> "Typically, policies and programs related directly to pesticide use are outside the purview of local planning and zoning regulation. However, some cities and counties have enacted regulations on pesticide use as part of their municipal code. Local governing bodies may pass ordinances that regulate or restrict pesticide use in their own operations. However, these restrictions do not apply to state operations and would not be applicable to treatments the District proposes under the Program because California state law preempts local regulation and restriction of pesticide use. The District is a regulatory agency formed pursuant to California Health and Safety Code Section 2000 et seq. State law charges the District with the authority and responsibility to take all necessary or proper steps for the control of mosquitoes and other vectors in the District (see Section 1.1.3)." (page 3-4)

See the transcript from the public hearing held in Santa Rosa, California, on September 17, 2015 (T-Santa Rosa) for additional comments related to the other locations with regulations on pesticide use. Regulations in other cities and countries on pesticide use are outside the scope of the District's PEIR.

For additional responses to comments on glyphosate, please see responses to comments I-Fra3.

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I-Fra5

Marin/Sonoma Mosquito and Vector Control District's
Integrated Vector Management Program Draft PEIR

WRITTEN COMMENT

Name/Affiliation: Mary Fraser Date: 9/12/15

Address: [redacted]

City: Mill Valley Zip Code: 94941 Telephone [redacted]

Please provide comments and concerns on the content of the Draft PEIR and the potential environmental effects of the Proposed Program.

Please see the attached document - "A Generation in Jeopardy - How Pesticides are Undermining our Children's Health and Intelligence -

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1

peir@msmosquito.com

Please use backside of page for additional comments, if needed. This comment form may be handed in at the public hearing to District staff or mailed to the attention of Philip Smith, to arrive on or prior to **October 2, 2015** at the Marin/Sonoma Mosquito and Vector Control District, 595 Helman Lane, Cotati CA 94931.

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A Generation in Jeopardy

How pesticides are undermining our children's health & intelligence

PESTICIDE ACTION NETWORK NORTH AMERICA

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Pesticide Action Network North America

Pesticide Action Network North America (PAN North America) works to replace the use of hazardous pesticides with ecologically sound and socially just alternatives. As one of five PAN Regional Centers worldwide, we link local and international consumer, labor, health, environment and agriculture groups into an international citizens' action network. This network challenges the global proliferation of pesticides, defends basic rights to health and environmental quality, and works to ensure the transition to a just and viable society.

Acknowledgements

This report would not have been possible without the dedicated and careful work of hundreds of scientists at academic institutions in the U.S. and around the world. The contribution of these researchers to our collective understanding of the links between pesticide exposure and children's health is truly invaluable.

A Generation in Jeopardy also reflects the efforts and expertise of many individuals both within Pesticide Action Network and among our partner organizations and institutions. Susan Kegley, Heather Pilatic, Linda Wells and Kathryn Gilje provided useful comments and direction as the report was being developed and finalized. Several academic reviewers representing expertise in neurodevelopmental and carcinogenic impacts of pesticides on children's health provided substantive comments. Laura Cossette, Kristen Parks and Maria Reyna provided valuable research assistance.

Thanks also go to Brenda J. Willoughby who formatted the report for publication, Sara Knight who tracked down images, created figures and otherwise assisted immeasurably with production, Mateo Rutherford and Roy Rojas of Berkeley Interpretation, Translation and Transcription Services (BITTS) who translated the Executive Summary into Spanish, and Janet Stephens and Kathryn Gilje for final proofing and copy editing.

Funding for this report was provided by The A&A Fund, the Arntz Family Foundation, the Bellwether Foundation Inc., The California Endowment, the Cedar Tree Foundation, the Ceres Foundation, the Ceres Trust, the David B. Gold Foundation, the Fred Gellert Family Foundation, the Kresge Foundation, the McKnight Foundation, the Roy A. Hunt Foundation and the Wallace Genetic Foundation, as well as PAN's supporting members.

The authors bear responsibility for any factual errors. Recommendations and views expressed are those of Pesticide Action Network North America, and do not necessarily represent the views of our funders and supporters.

Special thanks to our colleagues at Californians for Pesticide Reform (CPR), Tracey Brieger and Sarah Aird, for strategic thinking and input as the report was being conceived and drafted, as well as assistance with the report's release and dissemination. PAN North America is a member of CPR, and is releasing this report in partnership with the coalition. The CPR coalition includes over 185 public interest organizations committed to improving and protecting public health, sustainable agriculture, and environmental quality by building a movement across California to change statewide pesticide policies and practices. See www.PesticideReform.org or call 510-788-9025 for more information about CPR's statewide work.

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A Generation in Jeopardy

How pesticides are undermining our children's health & intelligence

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October 2012
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A Generation in Jeopardy

Executive Summary

Children today are sicker than they were a generation ago. From childhood cancers to autism, birth defects and asthma, a wide range of childhood diseases and disorders are on the rise. Our assessment of the latest science leaves little room for doubt: pesticides are one key driver of this sobering trend.

As the recent President's Cancer Panel reports, we have been "grossly underestimating" the contribution of environmental contamination to disease, and the policies meant to protect us have fallen far short. Nearly 20 years ago, scientists at the National Research Council called for swift action to protect young and growing bodies from pesticides.[1] Yet today, U.S. children continue to be exposed to pesticides that are known to be harmful in places they live, learn and play.

This report reviews dozens of recent studies that examine the impact of pesticides on children's health. Our analysis reveals the following:

- **Compelling evidence now links pesticide exposures with harms to the structure and functioning of the brain and nervous system.** Neurotoxic pesticides are clearly implicated as contributors to the rising rates of attention deficit/hyperactivity disorder, autism, widespread declines in IQ and other measures of cognitive function.
- **Pesticide exposure contributes to a number of increasingly common health outcomes for children, including cancer, birth defects and early puberty.** Evidence of links to certain childhood cancers is particularly strong.
- **Emerging science suggests that pesticides may be important contributors to the current epidemic of childhood asthma, obesity and diabetes.**
- **Extremely low levels of pesticide exposure can cause significant health harms,** particularly during pregnancy and early childhood.

Children's developing bodies are particularly vulnerable to the health harms of pesticides.

Prioritizing children's health requires real change

As a nation, we value the wellbeing of our children. In addition to our natural urge to protect what we love, we know that at a societal level their successful development is key to a vibrant, secure future. Poll after poll shows more than 80 percent of Americans consider healthy children a top priority. We must line up our practice and policies with these values.

Many communities across the country have stepped up to create local or state policies to protect children from pesticide exposure. From pesticide-free schools, parks and playgrounds to protective buffer zones in agricultural areas, locally-driven actions are leading the way to healthier childhood environments.

But to ensure protection of all children from the harms of pesticides, we must dramatically reduce the use of these chemicals nationwide. An estimated 1.1 billion

pounds of pesticides are used in the U.S. every year, with more than 20,000 products on the market. This volume of use is undermining the health of the next generation and, as the science demonstrates, derailing development of our children's potential.

Scientists have understood for decades that children are particularly vulnerable to the harms of pesticide exposure. Quickly growing bodies take in more of everything; they eat, breathe and drink more, pound for pound, than adults. As physiological systems undergo rapid changes from the womb through adolescence, interference from pesticides and industrial chemicals—even at very low levels—can derail the process in ways that lead to significant health harms.

Reducing overall pesticide use would not only limit children's exposure during their most vulnerable years, it would also lower pesticide levels in the bodies of men and women of childbearing age—protecting current and future generations in one fell swoop. Those pesticides most harmful to children should be first on the list.

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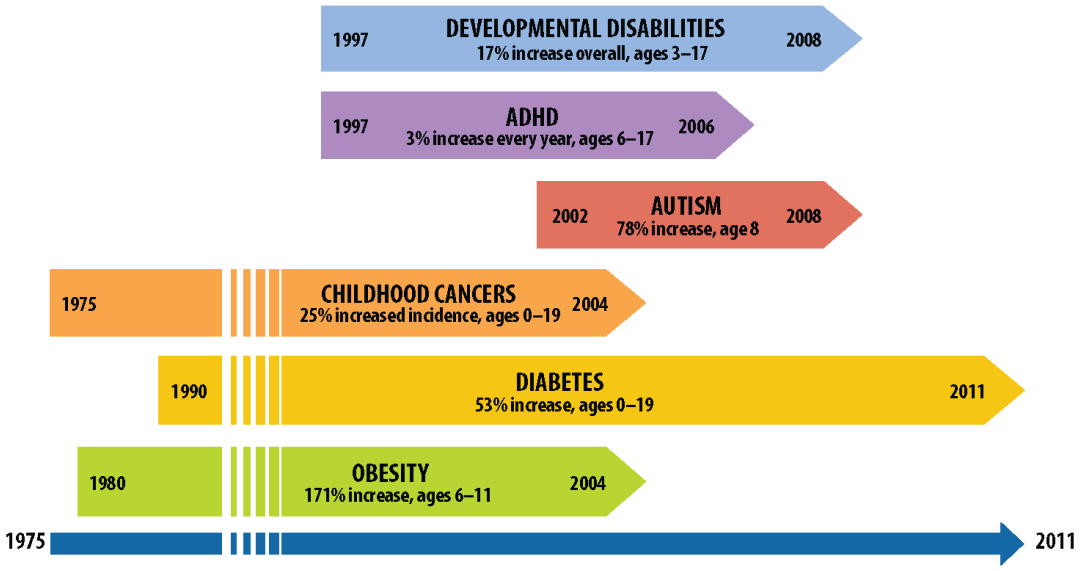
While we must each do what we can with food choices and decisions about home pest control, we cannot accomplish this goal at an individual household level. Policy change is required.

Effective policies urgently needed

To protect children from the health harms of pesticides, policymakers need much more effective tools. We believe change is most urgently needed in the way decisions are made about these three questions:

- Which pesticides are used in agriculture?
- Which pesticides are used in places children live, learn and play?
- How are farmers supported as they reduce reliance on pesticides?

Figure 1: Children's Health Harms on the Rise, 1975–2011*



Statistics show steady increases in many childhood diseases and disorders over the past 30 years. Those highlighted here are just some of the health harms on the rise.
Sources: see endnotes 4, 13,24, 52 and 94.

* With the exception of cancer, all other data are prevalence data, i.e., representing the U.S. population or based on data at several sites within the U.S. Prevalence is total number of cases in a population at a given time, while incidence is a measure of the number of new cases per year. The autism data are from 14 sites in the Autism and Developmental Disabilities Monitoring Network and are not considered fully representative of the U.S. population. The 1990 diabetes data are for type 1 only (type 2 being extremely rare among children at that time), while 2011 data include both type 1 and 2. Prevalence of type 2 diabetes among children is difficult to determine for various reasons, including difficulty of diagnosis.

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We recommend the following policy changes in each of these arenas:

1. Prevent the pesticide industry from selling agricultural products that can harm children's health

- *Take swift action on existing pesticides:* If studies find a pesticide to be a neurodevelopmental or reproductive toxicant, endocrine disruptor or human carcinogen—*and* it has been measured in humans, in schools or homes, or as residues on food or in drinking water—EPA should target the pesticide for rapid phaseout, triggering USDA resources to assist rapid farmer transitions to safer pest control methods.
- *Block harmful new pesticides:* EPA should not approve any new pesticide that scientific studies suggest is a neurodevelopmental or reproductive toxicant, endocrine disruptor or human carcinogen—including short-term "conditional" registrations.
- *Prevent harmful low-level exposures:* EPA should act on existing evidence that exposures to endocrine disrupting pesticides pose a particular danger to developing children; the long-delayed endocrine disruptor screening program (EDSP) should be swiftly implemented.

2. Protect children where they live, learn & play

- *Kid-safe homes, daycares & schools:* EPA should withdraw approval of existing pesticide products and not approve new pesticides for use in homes, daycare centers or schools when scientific evidence indicates the chemicals are possible neurodevelopment or reproductive toxicants, endocrine disruptors or human carcinogens.
- *Safer parks & playgrounds:* State and local officials should enact policies requiring that all public playgrounds, playing fields and parks be managed without using pesticides that studies show are harmful to children's health.

Table 1: Pesticides & Childhood Health Harms

		Childhood Health Harms*					
		Brain & nervous system impacts	Childhood cancers	Birth defects	Reproductive & developmental harms	Metabolic effects (e.g., obesity, diabetes)	Immune disorders, asthma
Pesticides	**Herbicides** 442 million lbs† *e.g., atrazine, glyphosate, 2,4-D*	✓	✓	✓	✓		✓
	Insecticides 65 million lbs *e.g., chlorpyrifos, malathion, permethrin*	✓	✓		✓	✓	✓
	Fungicides 44 million lbs *e.g., mancozeb, chlorothalonil*	✓	✓	✓	✓		✓
	Fumigants 108 million lbs *e.g., metam sodium, methyl bromide, chloropicrin*	✓	✓		✓		

Researchers have linked exposure to various pesticides with a range of childhood health harms. A ✓ indicates that links to the health harm are particularly well supported by scientific evidence.

* See Appendix A and www.pesticideinfo.org

† 2007 use estimates, refers to "active ingredient." From *Pesticide Industry Sales & Usage, 2006 and 2007 Market Estimates*, U.S. EPA, Washington, DC, Feb 2011. See www.epa.gov/opp00001/pestsales/07pestsales/market_estimates2007.pdf. Table 3.4.

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3. Invest in farmers stepping off the pesticide treadmill

- *Corral resources for farmers:* Federal and state officials should mobilize and coordinate existing resources to help farmers adopt well-known, effective pest management strategies that reduce reliance on pesticides.
- *Increase investment in innovative farming:* Congress should authorize significant funding for programs supporting farmers' adoption of sustainable practices that reduce use of harmful pesticides.
- *Set use reduction goals:* EPA and USDA should set specific and aggressive national pesticide use reduction goals, focusing first on pesticides that studies show to be harmful to children. To track progress toward this goal, farmers should work with applicators and pest control advisors to report their pesticide use to a nationally searchable database.
- *Source for children's health:* Food distributors should require that their suppliers limit use of pesticides that harm children's health.

These proposals are all common-sense measures in the face of clear evidence that our children's wellbeing is at risk. It's time to muster the political will to prioritize the health of our children, grandchildren and future generations.

Even at very low levels, pesticide exposure can derail development and undermine the ability to learn.

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1 Brainpower at Risk

New studies find pesticides can compromise intelligence

Knowledge of environmental causes of neurodevelopmental disorders is critically important because they are potentially preventable. — Dr. Philip Landrigan

The process of establishing the architecture of the human brain begins in the womb and continues into early adulthood. During this long window of development, many complex processes take place, involving tens of billions of nerve cells making trillions of connections. Cells migrate from one section of the brain to another, and nerve tracts are laid as the final structure of the brain is created.

Many of the processes that occur during brain development are vulnerable to disruption from pesticides. Exposure to neurotoxic pesticides during critical moments of fetal development, even at very low levels, has been shown to fundamentally alter brain architecture.[2] Pesticides that disrupt the hormone system—and particular those affecting the functioning of the thyroid, which plays a key role in brain development—can cause lasting damage. The impacts of exposures are often irreversible because unlike other organs, the brain cannot repair damaged cells (see sidebar).

Children whose brain infrastructure or nervous system fails to develop normally may be disabled for the rest of their lives. Developmental disabilities include autism spectrum disorders, attention deficit disorders, hearing loss, intellectual impairment and vision loss. People with developmental disabilities are often challenged by everyday life activities such as language, mobility, learning and independent living. Reduced cognitive abilities can also lead to behavioral problems, from aggression and social alienation to increased risk of drug abuse.[3]

A "Silent Pandemic"

Some 15 percent of all U.S. children have one or more developmental disabilities—representing a 17 percent increase in the past decade. For some disorders, the numbers are rising even more rapidly.[4] Overall, researchers estimate that between

Mechanisms of Harm

Misfiring neurons & altered brain architecture

Pesticides can interfere with brain function and development in several ways; we describe three of the most common and best understood mechanisms of harm here:

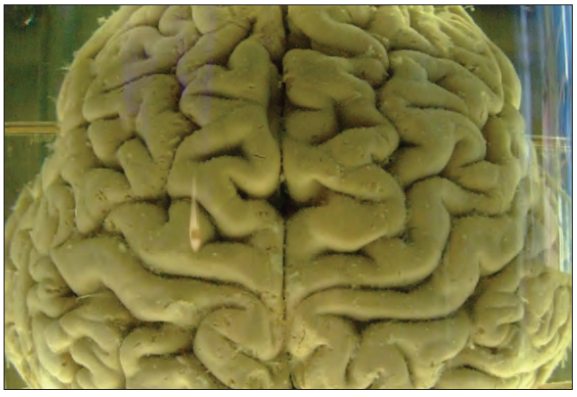
Neurotransmitter control: Organophosphate pesticides can block the normal functioning of acetylcholinesterase, an enzyme that degrades—and thus controls—a neurotransmitter called acetylcholine. When the functioning of the enzyme is blocked, acetylcholine is not degraded and neurons continue firing instead of shutting down after they've accomplished their mission. This can cause serious problems in the normal functioning of the nervous system.

Developing brain cells: To date, EPA assessments have relied on acetylcholinesterase levels as a marker of organophosphate exposure risk, yet studies now show adverse effects can occur at much lower doses than those that block acetylcholinesterase. For example, chlorpyrifos has been shown to interfere with neural cell replication, differentiation and survival. As the brain structure is developing—particularly at key stages *in utero*—chlorpyrifos can disrupt the process in ways that permanently alter the architecture of the brain.*

Sodium flow into nerve cells: Pyrethroid insecticides act on neurons by perturbing voltage-sensitive sodium channels. These sodium "gates" are what allow sodium to flow into a nerve cell, controlling how a neuron fires and transmits signals along a nerve. Pyrethroids cause these gates to open and close more slowly, changing how the nerve cell normally responds—either inducing repetitive firing or causing the nerve cell not to fire at all.†

* Rauh, V. A., F. P. Perera, M. K. Horton, R. M. Whyatt, R. Bansal, X. Hao, et al. "Brain Anomalies in Children Exposed Prenatally to a Common Organophosphate Pesticide." *Proceedings of the National Academy of Sciences.* May 2012 109 (20): 7871-6. See http://www.pnas.org/cgi/doi/10.1073/pnas.1203396109.

† Shafer T.J., D.A. Meyer and K.M. Crofton. "Developmental neurotoxicity of pyrethroid insecticides: critical review and future research needs." *Environ Health Persp.* Feb 2005 113(2):123-36. See http://www.ncbi.nlm.nih.gov/pubmed/15687048.



Pesticides can interfere with brain function in several ways, from altering architecture during fetal development to interfering with neurostransmitter control. Gaetan Lee

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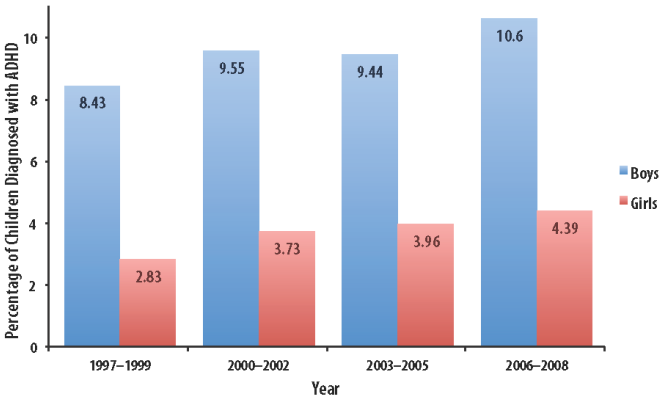
Figure 2: ADHD Prevalence among Children Ages 3 to 17, from 1997–2008



The number of children diagnosed with ADHD increased an average of 3 percent every year from 1997 to 2008. Boys are much more likely to be affected. Source: C. Boyle et al., "Trends in the Prevalence of Developmental Disabilities in U.S. Children, 1997– 2008."

400,000 and 600,000 of the four million U.S. children born each year are affected by a neurodevelopmental disorder.[5]

Public health experts from Harvard and Mt. Sinai Hospital have called the damage that chemicals are causing children's developing minds a "silent pandemic,"[6] and scientists now point to a combination of genetic and environmental factors to explain this rapid rise of developmental, learning and behavioral disabilities.[7]

Some children, for example, may have a genetic susceptibility to attention deficit/hyperactivity disorder (ADHD) or autism, but it may only develop if the child is exposed to a triggering chemical during a certain period of development. Other children may be genetically programmed to produce less of a common detoxifying enzyme, rendering their brain and nervous system more susceptible to lasting harm when they are exposed to neurotoxic pesticides (see sidebar, p. 25).[8]

Genetic mutations that occur in parents (both men and women) in response to chemical exposures over the course of their lifetime can also, according to recent research, raise the risk of neurodevelopmental disorders for their children.[9, 10]

The National Academy of Sciences now estimates that about one third of all neurobehavioral disorders (such as autism and ADHD) are caused either directly by pesticides and other chemicals or by interaction between environmental exposures and genetics.[11] Some experts say this estimate is likely to be low, as the health profession is just beginning to fully recognize the contributions of environmental factors to disease formation.*

Whatever the mechanism of harm, recent studies leave little doubt that exposures to pesticides during fetal development, infancy and childhood may contribute significantly to decline in the cognitive abilities of our children. A recent comprehensive review of the science on health effects of pesticides by the Ontario College of Family Physicians found exposure to pesticides in the womb to be "consistently associated with measurable deficits in child neurodevelopment."[12]

We look here at three areas where the evidence is particularly strong: ADHD, autism and falling IQs. A few of the key studies are highlighted below, and more detailed descriptions—along with additional studies—are provided in Appendix A.

ADHD rates continue to rise

ADHD is quite clearly on the rise, and though changes in diagnosis play a role, this cannot fully explain the trend. The number of children diagnosed with ADHD increased an average of three percent every year from 1997 to 2006, and an average 5.5 percent per year from 2003 to 2007 (see Figure 2).[13, †]

The Centers for Disease Control and Prevention (CDC) estimates that ADHD now affects three to seven percent of all school children in the U.S.; one independent study puts the figure at 14 percent.[14] Boys are much more likely to be diagnosed with ADHD, although the American Psychological Association notes that girls are more likely to suffer from the "attention deficit" part of the disorder, and their symptoms are often overlooked.[15]

A variety of brain functions are compromised in children exhibiting ADHD. Learning is often impaired, and those with the disorder may exhibit impulsive behavior and hyperactivity, and lack the ability to sustain attention.

As with other neurodevelopmental disorders, the social impacts can be immense. Parents report that children with ADHD have almost three times as many problems interacting with peers as children without. Diagnosed children are almost 10 times as likely to have difficulties that interfere with friendships, including experiencing exclusion from peer groups.[16]

The Science

Researchers estimate that from 20 to 40 percent of ADHD cases are caused by something other than genetics.[17] Studies have found links to a variety of environmental contaminants, including exposure to organophosphate and pyrethroid insecticides during pregnancy and throughout childhood.

* See for example the 2010 President's Cancer Panel report "Reducing Environmental Cancer Risk: What we can do now" http://deainfo.nci.nih.gov/advisory/pcp/annualReports/index.htm.

† The CDC outlines diagnostic criteria here: http://www.cdc.gov/ncbddd/adhd/diagnosis.html, specifying that children must display at least six characteristic behaviors within six months, and that some symptoms must be present before the age of seven. CDC explains shifts in diagnostic criteria here: http://www.cdc.gov/mmwr/preview/mmwrhtml/ss5810a1.htm.

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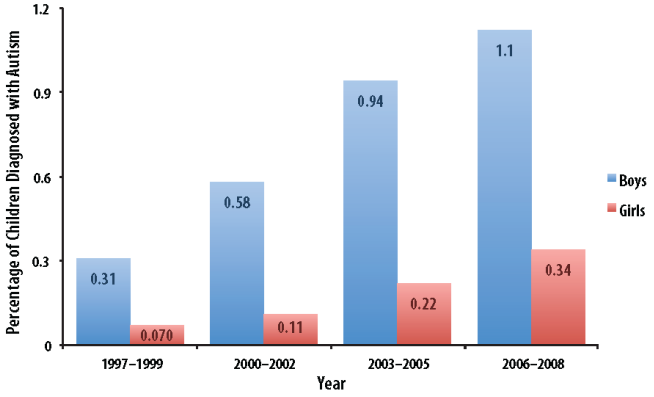
- Children with higher levels of organophosphate breakdown products in their urine were more likely to have ADHD. Researchers found that 94 percent of the 1000+ children tested by CDC had detectable levels of these metabolites, and those with levels above the median were twice as likely to be diagnosed with ADHD as those with no metabolites found.[18]
- Organophosphate metabolites at levels commonly found in the bodies of U.S. children are linked to increased likelihood of ADHD. Every 10-fold increase in levels of organophosphate metabolites in the urine of children aged eight to 15 years was associated with a 55 to 72 percent increased likelihood of the disorder.[19]
- Prenatal organophosphate exposure has been linked to attention problems. Each ten-fold increase in a pregnant mother's urinary concentration of organophosphate metabolites led to a five-fold increased risk that her child would be diagnosed with ADHD by age five.[20]
- Children with low birth-weight are more likely to have ADHD,[21] and there is considerable evidence linking reduced birth-weight with prenatal exposure to organophosphate pesticides.[22]
- Mouse pups were hyperactive after being exposed to the pyrethroid insecticides pyrethrin or cypermethrin, and adult mice injected with permethrin or deltamethrin had long-term elevation of the dopamine transporter, a marker that has been linked to ADHD.[23]

Table 2:
Chemicals Contributing to Autism

- Lead
- Methylmercury
- Polychlorinated biphenyls
- **Organophosphate pesticides**
- **Organochlorine pesticides**
- **Endocrine disruptors**
- Automotive exhaust
- Polycyclic aromatic hydrocarbons
- Brominated flame retardants
- Perfluorinated compounds

This list from public health experts includes both commonly used organophosphate pesticides and long lasting organochlorine pesticides, as well as other chemicals commonly found in consumer products. Source: Landrigan, et al., 2012

Figure 3: Autism Prevalence among Children Ages 3 to 17, from 1997–2008



Rates of autism have risen dramatically in the past decade. While overall prevalence is higher among boys, the rate of increase is higher among girls. Source: C. Boyle et al, "Trends in the Prevalence of Developmental Disabilities in U.S. Children, 1997–2008."

Autism rates jump 250% in one decade

The autism spectrum includes classic autism, Asperger's Syndrome and atypical autism. Incidence rates have risen rapidly in recent years; in its 2012 report, CDC estimated—based on 2008 data on eight-year-olds from 14 states—that 1.1 percent of U.S. children, or one in every 88, are now on the autism spectrum. Boys are more likely to have the disorder, with one in 54 affected.

Data from the National Health Interview Surveys reveal a dramatic rate of increase. Between 1997 and 2008, autism prevalence among boys ages three to 17 years increased 261%. Prevalence among girls, while much lower than boys overall, rose even more quickly, showing an increase of more than 385% over the same period (see Figure 3).[24]

In California, the number of children with autism who are enrolled in statewide programs rose from 3,864 in 1987 to 11,995 in 1998, an increase of more than 210 percent in 11 years.[25] Other states saw similar rates of increase between 2002 and 2006.[26] Though shifts in diagnosis account for some of this dramatic rise, public health experts have determined that diagnostic changes do not fully explain the trend.

Researchers believe autism spectrum disorders reflect changes in brain structure occurring during critical windows of development in the womb. These shifts in brain architecture may be caused by genetics, environmental insults such as chemical exposure, or an interaction between the two.[27, 28]

In 2012, a group of researchers led by Dr. Philip Landrigan of Mt. Sinai Medical Center released a list of ten types of chemicals most likely to be linked to the development of autism (see Table 2), and laid out an urgent strategy for research into the role of these contaminants and how children can be better protected from them. The list includes both commonly used organophosphate pesticides and longlasting organochlorine

pesticides, as well as other chemicals commonly found in consumer products.[29]

The Science

Studies examining the links between pesticide exposure and autism suggest prenatal exposures are particularly damaging.

- One study in California's Central Valley found that when mothers were exposed early in pregnancy to the organochlorine pesticides endosulfan and dicofol, the risk of autism among their children increased sharply. Children whose mothers lived within 500 feet of fields being sprayed were six times more likely to be on the autism spectrum.[30]
- Mothers in California's central coast region who had higher levels of organophosphate metabolites in their urine during pregnancy were much more likely to have children with pervasive developmental disorder—which can include or be an indicator of autism. The risk more than doubled each time metabolite concentrations went up by a factor of 10.[31]
- A study in New York City found that infants most exposed to chlorpyrifos *in utero* were significantly more likely to have pervasive developmental disorders—including autism—by the time they were three years old.[32]
- A trio of U.S. studies examined links between environmental exposures among parents (including, but not limited to, pesticides) and incidence of autism among their children.[33] Among other findings, the scientists reported that older fathers are more likely to transmit tiny, spontaneous gene mutations—that occur over a lifetime in response to environmental stressors—to their offspring, that in turn increase the risk of autism. Recent research in Iceland confirmed these findings.[34]
- Minnesota researchers explored the interaction of exposure to organophosphate pesticides, gene expression and dietary factors as potential contributors to autism.[35] Among other things, they found that mineral deficiencies linked to high fructose corn syrup consumption* make developing minds more susceptible to the neurotoxic effects of pesticides.

These various recent studies show how complex the path to our current autism epidemic has been. But evidence suggests that pesticide exposure—particularly during pregnancy—is implicated in a number of ways.

Derailed brain development means falling IQs

The societal implications of reduced cognitive abilities across an entire generation are nothing short of staggering and have been a concern among public health specialists since the IQ effects of lead exposure became clear in the 1970s. As Dr. Ted Schettler observed back in 2000:

> A loss of five points in IQ is of minimal significance in a person with an average IQ. However a shift of five IQ points in the average IQ of a population of 260 million increases the number of functionally disabled by over 50 percent (from 6.0 to 9.4 million), and decreases the number of gifted by over 50 percent (from 6.0 to 2.6 million).[36]

* High fructose corn syrup is found in a wide range of processed foods and beverages.

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Twelve years later, Dr. David Bellinger echoed this observation. He pointed out that cognitive effects, often dismissed as "clinically unimportant" at the individual level, become very significant across a whole society in terms of declining intellectual capacity, lost economic productivity and increased costs for education and health care.

Bellinger reviewed published data linking organophosphates and cognitive effects, and concluded that overall, exposure to organophosphate insecticides may be responsible for lowering U.S. children's IQ level† by 17 million points—not much less than the 23 million point loss attributed to lead poisoning.[37]

Bellinger argues that because the potential impacts of organophosphates are so widespread and significant to society, "a risk assessment that focuses solely on individual risk, and fails to consider the problem in a public health context" is misleading and will not lead policymakers to sound and protective decisions.

The Science

Pesticide exposure during pregnancy can have dramatic effects on cognitive development. From a wide range of animal research to studies tracking the intellectual development of children over time, the evidence points squarely at prenatal pesticide exposures as significantly harming the development and functioning of the brain. These harms can then lead to both lower IQ levels and neurodevelopmental delays.

- A particularly compelling study used Magnetic Resonance Imaging (MRI) technology to observe the developing brains of infants who had been exposed to chlorpyrifos during pregnancy. Researchers observed significant structural changes, including abnormal areas of thinning and enlargement. Areas of the brain related to attention, language, reward systems, emotions and control were affected.[38]
- Three cohort studies‡ released in 2011 document cognitive impairment caused by exposure to organophosphates in the womb.§ The first study found that higher metabolite levels in a mothers' urine late in pregnancy increased the likelihood of reduced cognitive development in their children.[39] The second study linked prenatal exposure to a seven-point reduction in IQ by age seven.[40] The third study found that even very low levels of chlorpyrifos residues in cord blood resulted in lower IQ and reduced working memory.[41]
- Pregnant mothers exposed to chlorpyrifos through household use (before this use was withdrawn)¶ had infants with lower birth weight and reduced head circumference, both indicators of impaired cognitive ability later in childhood.[42]

† The accuracy of Intelligence Quotient (IQ) testing to measure intellectual capacity has long been a source of contention, but IQ is currently the best index for measuring cognitive abilities across a population.

‡ See sidebar in Appendix A for a description of the various types of scientific studies highlighted in this report.

§ See this editorial in *Environmental Health Perspectives* for a discussion of the importance of these three studies: "Strength in Numbers: Three Separate Studies Link In Utero Organophosphate Pesticide Exposure and Cognitive Development," available online at: http://ehp03.niehs.nih.gov/article/fetchArticle.action?articleURI=info%3Adoi%2F10.1289%2Fehp.1104137

¶ Chlorpyrifos was withdrawn from home use in 2001, but remains widely used in agricultural settings where farm, farmworker and rural community mothers and children still face exposure. Children also continue to be exposed from residue on fruits and vegetables.

- Exposure to the organophosphate pesticides diazinon and parathion during early childhood may reduce cognitive function, according to results from animal studies. Low-dose exposures caused changes in the developing brains of rats known to correspond to reduced ability to learn.[43] Other animal studies indicate that *in utero* and neonatal exposure to organophosphates increases the risk of developmental delays.[44]
- Children at three months of age who were most highly exposed to the pyrethroid pesticide synergist piperonyl butoxide,* as assessed by personal air monitors, scored 3.9 points lower on the Bayley Mental Developmental Index. These scores are predictive of school readiness, and the authors described their results as modest, yet "worrisome."[45]
- Prenatal exposure to the DDT† breakdown product DDE is also associated with neurodevelopmental delays in children, especially the "psychomotor" skills linking movement or muscular activity with mental processes.[46] And exposure *in utero* to DDT itself has been associated with reduced cognitive functioning, memory and verbal skills among preschoolers.[47]

Strong emerging evidence links childhood pesticide exposure to other, adult-onset neurological effects such as Parkinson's and Alzheimer's diseases; these studies are not examined here.[48]

The combined, society-wide impact of the various syndromes, disorders and deficits resulting from damage to children's brains and nervous systems early in life is immense. Health professionals and educators across the country have indicated concern that our current policies don't adequately protect our children as their nervous systems develop.[49] Something must be done to address this gap, as the results of such exposures have profound consequences for individuals, families and society as a whole.

I-Fra5

Exposure of a developing fetus, infant or child to neurotoxic pesticides can lead to greater risk of learning disabilities and significant drops in IQ.

* Piperonyl butoxide, or PBO, is commonly included in formulations of pyrethroid pesticide products to increase the potency of the active ingredient.

† Agricultural uses of DDT were banned in the U.S. in 1972, but because of its persistence, DDT and its breakdown products continue to appear in human blood samples. DDT use continues in some countries for malaria control programs.

I-Fra5

2 Cancer, Birth Defects & Early Puberty

Latest science links many childhood health harms to pesticide exposure

If we are going to live so intimately with these chemicals—eating and drinking them, taking them into the very marrow of our bones—we had better know something about their nature and their power. —Rachel Carson

Our children face a range of health challenges that were not encountered by past generations. Public health experts are concerned, and are increasingly focusing on the contributing role of environmental factors such as pesticides and other chemicals.

The President's Cancer Panel's 2010 report, for example, concluded that the role environmental contaminants play in contributing to cancer has been "grossly underestimated" and called for urgent action to reduce the current widespread exposure to carcinogens. The Panel's chair, Dr. LaSalle Leffall, urged preventative measures to protect public health—even in the face of some uncertainty.*

> The increasing number of known or suspected environmental carcinogens compels us to action, even though we may currently lack irrefutable proof of harm.[50]

Meanwhile, evidence continues to mount linking chemical exposure to a range of children's health harms. Below we present a summary of some of the growing body of recent findings on pesticides and childhood cancer, birth defects and early puberty. More detailed descriptions and additional studies are included in Appendix A.

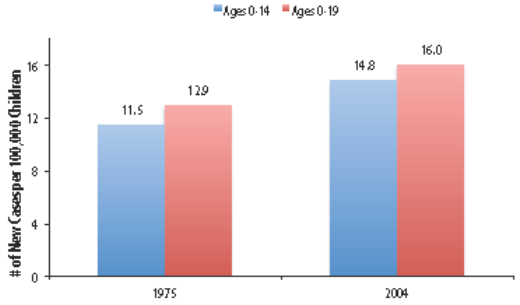
Some childhood cancers linked to pesticides

Cancer is the second most common cause of death among U.S. children one to 14 years old.† Over the past 30 years, the number of children diagnosed with all forms of invasive cancer has increased 29 percent, from 11.5 cases to 14.8 cases per 100,000 children per year (see Figure 4).[51]

There are many types of childhood cancer, and incidence rates vary widely. Leukemia and childhood brain cancers are now the most common cancers among children, with rates for these two cancers rising 40 to 50 percent since 1975: leukemia from 3.3 to 4.9 per 100,000 children, and brain cancers from 2.3 to 3.2 (see Table 3).[52]

Survival rates have also risen. Improved cancer treatments have led to dramatic increases in survival of all types of childhood cancer, particularly leukemia (from 50 percent survival in 1975 to more than 80 percent in 2004) and non-Hodgkins lymphoma (from 43 to 87 percent survival over the same time period.) For all types of childhood cancers, African-American children have a lower survival rate than do white children (73 vs. 81 percent).[53]

Figure 4: Incidence of Cancer among Children, 1975 & 2004



Over the past 30 years, the number of children diagnosed with all forms of cancer has increased from 11.5 to 14.8 cases per 100,000 children per year.
Source: SEER, 2004

Table 3: Top 5 Childhood Cancers

- Leukemia
- Brain and other nervous system tumors
- Neuroblastoma
- Wilms' tumor
- Lymphoma

The types of cancers that occur most often in children are different from those seen in adults.
Source: American Cancer Society

For some cancers, genetics is a powerful predictor. But as outlined by the President's Cancer Panel, cancers can have multiple and often interacting causes. In some cases genetic factors make an individual more susceptible, and exposure to environmental carcinogens may trigger cancer development.

The Science

A large number of recent studies link pesticide exposure to childhood leukemia, brain tumors and neuroblastoma. Some evidence suggests pesticide exposure may also be associated with other types of children's cancer, such as non-Hodgkin's lymphoma, Wilms' tumor and Ewing's sarcoma. Many studies

* This call for action in the face of some uncertainty is an example of the "Precautionary Principle," an approach to decision making that has been adopted by many local governments in the U.S. and in countries around the world. For a definition and more information, see the Science and Environmental Health Network's FAQ: http://www.sehn.org/ppfaqs.html

† Lethal accidents are the most common cause of death.

find *in utero* exposure during key windows of fetal development or parental exposure before conception to be particularly important.

- Home insecticide use during pregnancy can increase risk of childhood leukemia, according to a review of 15 studies over the past two decades. Timing of exposure appears to be particularly important.[54]
- The risk of a child developing acute lymphocytic leukemia—the most common type of childhood leukemia—is higher when the mother is exposed to home insecticides during pregnancy. Risk increased with the frequency of the mother's exposure; the highest risk was associated with use of household insecticides more than five times over the course of gestation.[55]
- Mothers who have a particular genetic variant of an enzyme involved with the metabolic processing of wastes and toxins (including carcinogens)* are more likely to have a child with leukemia when they use pesticide products during pregnancy.[56]
- Several case-control studies link exposure to herbicides and household insecticides during pregnancy to an increased risk of childhood brain cancer.[57]
- Higher risk of neuroblastoma, the most common cancer among infants, was observed in children whose parents reported garden and home pesticide use.[58] An older case-control study of U.S. and Canadian children indicated increased risk of neuroblastoma among children whose fathers were landscapers and groundskeepers.[59]
- In a national case-control study in Australia, increased risk of Ewing's sarcoma tumors among children was linked to occupational exposures of mothers and fathers who worked on farms around the time of conception.[60]
- Children who lived in areas of high agricultural activity in the U.S from birth to age 15 experienced significantly increased risk of childhood cancers.[61] And a study in Norway of agricultural census data found that of 323,359 children under 14, those who grew up on a farm—combined with a high level of pesticides purchased by the family—were nearly twice as likely have brain tumors.[62]

A number of studies—not reviewed here—explore potential links between prenatal or childhood pesticide exposures and incidence of cancers later in life. For example, according to the President's Cancer Panel, girls who were exposed to DDT before they reach puberty are five times more likely to develop breast cancer in middle age.[63]

In general, the association between pesticide exposures and childhood cancer outcomes may be underestimated, as data are somewhat limited and studies focus on certain cancers more than others. In addition, common methodological problems—such as occupational exposures being identified only through self-reporting or job title, considerations of other routes of exposure, small sample sizes, and relying on recall to estimate exposures—may contribute to skewed findings.[64]

* The CYP1A1 gene codes for the expression and activity level of an enzyme that helps clear the body of potentially harmful compounds.

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Birth defects rise with seasonal or occupational exposures

Birth defects are the leading cause of infant mortality in the U.S., accounting for 19 percent of the 29,138 infant deaths in 2007. And the overall incidence of birth defects is rising.[65] According to CDC data, about one in every 33 babies born today has some kind of birth defect.[66] Birth defects can affect almost any part of the body; some are mild and impact appearance only, others affect the functioning of organs and can be life threatening, although overall survival rates have increased significantly since 1979.[67]

Incidence trends vary by specific birth defect. Cleft lip/palate is the most common birth defect reported, and incidence has declined slightly over the last decade. Rates of Down Syndrome, gastroschisis (an abdominal wall defect resulting in protrusion of the intestines) and anencephaly (absence of portions of the brain, skull and scalp) have all increased since 1999.[68]

Like many children's health outcomes, a combination of genetic and environmental factors is often at play. CDC's research on environmental factors has focused primarily on smoking, alcohol intake, obesity and diabetes.[69] Other scientists, however, have examined the role of parental exposure to pesticides and other chemicals before conception, and of mothers' exposure to environmental contaminants during pregnancy (see sidebar, p. 17).

The Science

Parents exposed to pesticides occupationally, from exposures in their community or by in-home pesticide use may increase the risk of birth defects in their newborn. Studies indicate that exposure of both mothers and fathers, particularly during the period of conception, can influence birth defect outcomes. Several studies in agricultural areas have correlated conception during peak pesticide spray season with increased birth defect risk.

A mother's exposure during pregnancy can also play a key role, with specific timing once again emerging as a critically important variable.

Children whose mothers were exposed to herbicides and household insecticides during pregnancy have an increased risk of developing brain cancer.

Farmworker Families & Pesticides

As a community organizer and health educator in North Carolina, Ana Duncan Pardo works with many communities directly affected by pesticides.

When we spoke with Ana about her experience working with farmworkers, she described a particular instance—when she was setting up for a presentation to farmworker parents—that awoke her to the health harms faced by many of these families:

> Within five minutes I had noted multiple cleft palates and several children with apparent Down Syndrome.... It was shocking and disturbing to walk into a room with a group of parents and children that easily represented three to four times the national average for birth defects.

Farmworkers and their families face unique risks, as the harmful chemicals applied in the field follow workers home on their skin, shoes and clothing, and may also drift into their homes from the nearby fields. And, like all families, the food they eat every day may contain pesticide residues.

Ana Duncan Pardo is the farmworker organizer & communications coordinator for Toxic Free North Carolina, and a member of PAN's board.

- A multi-year, national review of USGS water data and CDC birth defect records found a strong seasonal association between birth defects and the presence of the herbicide atrazine in surface water. Infants conceived between April and July, when elevated concentrations of the herbicide are found, have a significantly higher birth defect risk (see Figure 5).[70]
- In Washington state, a seasonal analysis of the risk of the abdominal wall defect gastroschisis showed prevalence peaking when conception occurred between March and May. The birth defect occurred most frequently among infants whose mothers lived within 50 kilometers of a site with high surface water concentration of atrazine.[71]
- Male pesticide applicators in Minnesota had a significantly higher number of children with birth defects, in a study examining 4,935 births to pesticide applicator fathers over three years. The birth defects were more common among boy offspring than girls.[72] Egyptian fathers exposed to pesticides at work also had a greater risk of having children with congenital malformations.[73]
- Increased risk of boys' urogenital malformations such as hypospadia, micropenis and cryptorchidism* has been linked in many studies to prenatal exposure to environmental contaminants. One recent meta-analysis of studies from seven countries (Canada, Denmark, Italy, Netherlands, Norway, Spain and the U.S.) indicated a 36 percent increased risk of hypospadia when mothers were exposed to pesticides at work, and a 19 percent increased risk with fathers' occupational exposure to pesticides.[74]

* Hypospadia is a defect in which the urethral opening develops in the wrong location along the shaft of the penis. Micropenis is a defect where boys have severely reduced penile size, and cryptorchidism is a defect where the testes descend improperly, or not at all.

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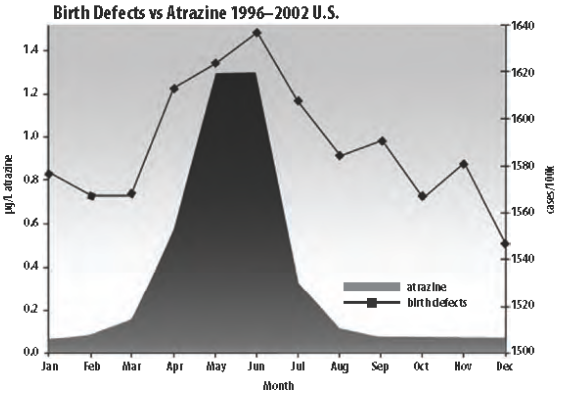
Figure 5: Atrazine Seasonal Exposure & Birth Defects



Seasonal exposure to pesticides during pregnancy has been linked to increased risk of birth defects. Source: Winchester, P.D., J. Huskins and J. Ying. "Agrichemicals in surface water and birth defects in the United States." Acta Paediatrica. 2009 98: 664–669.

- The risk of having a child with neural tube defects, which are birth defects of the brain and spinal cord, has also been linked to pesticide exposure. Studies indicate a higher risk of this birth defect if insecticide bombs or foggers are used in the home during the period of conception. Risk is also higher if women live within a quarter mile of a cultivated field where pesticides are sprayed.[75]
- Mothers exposed to pesticides at work during a particular period of pregnancy have a significantly greater risk of having a child with anencephaly (a rare defect involving absence of a large part of the brain and skull).[76] A meta-analysis of studies examining fathers' exposure to Agent Orange (containing the herbicides 2,4-D and 2,4,5-T) found the risk of having offspring with spina bifida, a "split spine" defect caused by incomplete formation of the neural tube, was twice as high among those fathers who were exposed.[77] †

Many epidemiological studies over the years have found no association between pesticide exposure and birth defects. It must be considered, however, that these studies may not have taken timing of exposure into account, a variable that is proving to be a critical factor in birth defect outcomes. And as with cancer studies, results may be skewed by use of inappropriate surrogates for pesticide exposure (e.g. job title) or inaccurate subject recall.

Changes in puberty timing linked to low-level exposures

Young girls in the U.S. are moving from childhood to adolescence at an ever-younger age. Changes in the timing of sexual development over the past two decades have been so widespread that the age of "normal" puberty onset has been redefined by health professionals.[78]

† Agent Orange was widely used as a defoliant during the Vietnam War and was often contaminated with dioxins which have also been linked to birth defects. One of the herbicide ingredients, 2,4-D, is still in use in the U.S., and a proposal is currently under consideration for a genetically engineered variety of corn designed to allow increased 2,4-D application.

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Dr. Herman-Giddens and her colleagues first documented this acceleration in 1996, in a study finding that the number of girls having some sign of puberty onset before the age of eight was "substantially higher" than previously found.[79]

These initial findings of early puberty were corroborated in 2010 by researchers who found that by age seven, 10 percent of white girls, 23 percent of black non-Hispanic girls, and 15 percent of Hispanic girls had begun the process of breast development, also known as thelarche.[80] Some changes in pubertal development in boys have also been documented.

Changes in puberty timing are concerning for several reasons. For both boys and girls, self-esteem and body image issues can sometimes lead to self-destructive behaviors and poor performance in school. Additionally for girls, both early puberty and obesity (a contributing factor for early puberty) have been linked to health impacts later in life, increasing the risk for breast cancer and later reproductive health issues such as polycystic ovary syndrome.[81, 82]

These changes cannot be fully explained by ethnic, geographic, or socioeconomic factors, and thus a growing body of research has turned to examining the role of endocrine-disrupting chemicals in accelerating puberty in children.[83]

The Science

Although the number of studies is relatively small, researchers have found some associations between pesticide exposure—either during fetal development or early childhood—and effects on puberty.

Most studies focus on *in utero* exposures to pesticides with endocrine-disrupting effects that can interfere with the healthy development of the reproductive system—particularly if exposure occurs at certain times in the process (see sidebar).[84] The majority of studies focus on precocious puberty in girls, but a few studies have also found links between pesticide exposure and changes in the timing of puberty among boys.

Much of the research to date examines impacts of long-lasting organochlorine pesticides. Some of these are chemicals that have already been banned in the U.S. (e.g., DDT, hexachlorobenzene); others are in the process of being phased out (e.g., lindane, endosulfan); but all are still present in our food supply, environment, and in our bodies.[85, *] Though few studies have yet examined the connections, pesticides currently in use are also implicated in some studies.

- Prenatal exposure to the herbicide atrazine was linked to delayed pubertal development in both male and female rats in a recently released animal study.[86]
- Danish greenhouse workers exposed to a range of pesticides during pregnancy were more likely to have daughters showing breast development from 6–11 years old.[87] Increased likelihood of early puberty in girls in Jerusalem was found to coincide with seasons of intensified pesticide usage.[88]
- Daughters in Michigan were more likely to reach puberty at a younger age if their mothers had higher blood levels of the DDT breakdown product, DDE. Participants in this study included women who regularly consumed fish from the Great Lakes, which for years have been heavily contaminated with industrial pollutants such as PCBs and DDT.[89]
- Higher blood levels of hexachlorobenzene and DDE were associated with early puberty among Flemish boys.[90] Two recent studies of boys in India and Russia linked exposure to the pesticide endosulfan and the industrial by-product dioxin to delayed puberty among boys.[91]
- The pyrethroid insecticide esfenvalerate[†] has shown endocrine-disrupting effects related to puberty timing in female rats. Rats exposed to low levels (half of EPA's "no observable effect" level) for seven days showed significant delays in onset of puberty.[92]

As evidence mounts that developmental exposures to pesticides can have an effect on puberty timing, additional studies are now focusing on such endocrine-disrupting effects of pesticides currently in use.

Mechanisms of Harm

Endocrine disruption = development derailed

The term "endocrine" refers to systems in the body that are controlled by hormones, such as brain development, growth, reproduction and puberty. Hormones are chemicals synthesized in the body that bind to receptors to trigger actions at the cellular level resulting in physiological changes. Once their job is done they are released and free to act again.

Some pesticides act as "endocrine disruptors" that mimic hormones and can interfere with systems normally controlled by hormonal action. If such disruption occurs at times during development known as "windows of vulnerability,"—such as when the reproductive system is coalescing, brain or nervous systems are developing, immune system is forming or puberty is getting underway—the process can be derailed in significant ways, sometimes with life-long effects.

Because hormones themselves act at extremely low levels, biological processes controlled by hormones are tremendously sensitive. This means there often is no "threshold" or "safe" dose when it comes to endocrine disrupting compounds.*

* Zoeller, R.T., T. R. Brown, L. L. Doan, A. C. Gore, N. E. Skakkebaek, A. M. Sotp et al. "Endocrine-Disrupting Chemicals and Public Health Protection: A Statement of Principles from The Endocrine Society." *Endocrinology* June 2012. See http://endo.endojournals.org/content/early/2012/06/21/en.2012-1422.abstract.

Vandenberg, L., T. Colborn, T. Hayes, J. Heindel, D. Jacobs, D.H. Lee, et al. "Hormones and Endocrine-Disrupting Chemicals: Low-Dose Effects and Nonmonotonic Responses." *Endocrine Reviews.* March 2012 33(3): 378-455.

* CDC sampling from 1999–2000, for example, found DDT's breakdown product in blood samples of 99 percent of U.S. population. See http://www.cdc.gov/exposurereport/.

† Esfenvalerate is listed for Tier 1 screening under EPA's Endocrine Disruptor Screening Program. See http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0634-0001.

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3 Emerging Science
Obesity, diabetes & asthma

Chemicals that disrupt hormone messages have the power to rob us of rich possibilities that have been the legacy of our species and, indeed, the essence of our humanity. —Theo Colburn

Many of the health challenges facing children today have strong genetic and/or behavioral components. The rise in childhood obesity, for example, in part reflects the increasingly sedentary habits of many U.S. children.* But it's becoming increasingly clear that personal lifestyle choices do not tell the whole story.

The speed and scope of the society-wide rise in childhood health problems suggest a complex interaction of genetic, behavioral and environmental variables. Researchers are beginning to tease apart these interactions to more fully understand how exposure to environmental contaminants are involved.

We examine here the rapidly emerging science exploring how pesticides may contribute to the recent rise in childhood obesity, diabetes and asthma. Additional studies are included and described in Appendix A.

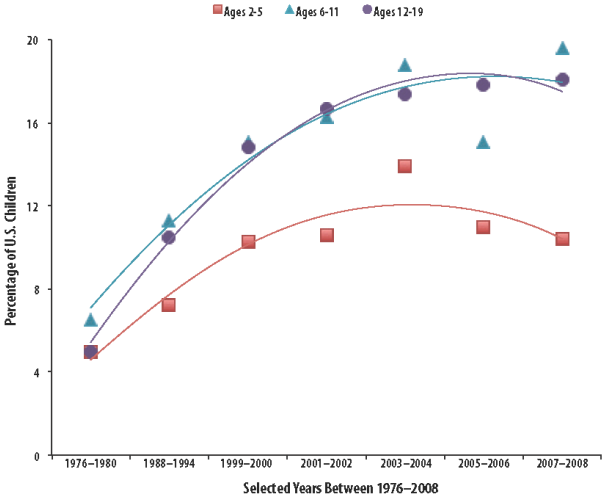
Childhood obesity, diabetes & disrupted metabolism

The recent dramatic rise in childhood obesity in the U.S. has the focused attention of health specialists and the public. The number of clinically obese children has more than tripled in the past 30 years, with obese children ages six to 11 jumping from seven percent of the total in 1980 to nearly 20 percent in 2008. The percentage of obese adolescents (12–19 years old) increased from five to 18 percent over the same period (see Figure 6).[93, †]

Obesity is closely linked to childhood diabetes, which is also on the rise. According to the National Institutes of Health, about 215,000 Americans under the age of 20 had diabetes in 2010—up from roughly 123,000 in 1990.[94, 95]

In addition to increasing related health risks, both obesity and diabetes can have a negative effect on quality of life in terms of ability to engage in physical activities, societal acceptance and self-image.

Figure 6: Prevalence of Obesity among Children Ages 2 to 19 between 1976–2008



Prevalence of obese U.S. children ages 6 -11 jumped from 7 percent in 1980 to 20 percent in 2008, while the percentage of obese adolescents increased from 5 to 18 percent. Source: Center for Disease Control, "Prevalence of Obesity Among Children and Adolescents: United States, Trends 1963-1965 Through 2007-2008."

The Science

So much new science exists around the links between obesity and environmental contaminants that a new term, "obesogen" (like carcinogen) has emerged in the literature.[‡] Findings increasingly suggest that exposures to pesticides and other chemicals play a role by altering developmental programming in ways that raise the likelihood of obesity and related metabolic effects such as diabetes.[96]

In 2002, Baillie-Hamilton reviewed data suggesting that the obesity epidemic coincided with the marked increase in usage of industrial chemicals, including pesticides, over the past 40 years (see Figure 7). The author suggested that pesticides and other industrial chemicals potentially cause weight gain by affecting the hormones that control weight, altering sensitivity

* CDC points to estimates that U.S. children spend an average 4.5 hours a day watching television and 7.5 hours using entertainment media (TV, computers, video games, cell phones and movies) as a contributing factor to childhood obesity. See http://www.cdc.gov/obesity/childhood/problem.html

† See CDC's "History of State Obesity Prevalence" showing trends in adult obesity by state from 2000-2010, at the bottom of this page: http://www.cdc.gov/obesity/data/adult.html

‡ See Wendy Holtcamp's review article, "Obesogens: An Environmental Link to Obesity" *(Environmental Health Perspectives,* Feb. 2012) for an overview of the current literature. Available online at http://ehp03.niehs.nih.gov/article/info%3Adoi%2F10.1289%2Fehp.120-a62#r13.

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to neurotransmitters, or altering the activity of the sympathetic nervous system.[97]

In the 10 years since this review, many studies have linked exposure to endocrine-disrupting chemicals with increased incidence of obesity and diabetes.[98] The National Institutes of Health is offering grants to study "the role of environmental chemical exposures in the development of obesity, type 2 diabetes and metabolic syndrome,"[99] and the National Children's Study, an ongoing 21-year prospective study of 100,000 U.S. children, is now exploring the hypothesis that prenatal exposures to endocrine disruptors are linked to obesity.[100]

- In one animal study, rats exposed to low-level doses of the organophosphate pesticide chlorpyrifos early in life developed metabolic dysfunction resembling pre-diabetes.[101]
- In Denmark, children exposed prenatally to pesticides through their mothers' work in greenhouses had significantly higher BMI (body mass index) scores than greenhouse worker mothers who were not occupationally exposed, with highly exposed children also having larger skin folds and higher body fat percentages.[102]
- Exposure to the pesticide lindane* during childhood has been linked with increased abdominal fat, increased waist circumference, higher BMI and fat mass percentage in adults.[103]
- Organochlorine pesticide exposure† can be a predictor of developing type 2 diabetes later in life, particularly among obese individuals. Serum concentrations of organochlorines were strongly associated with type 2 diabetes, and the association was stronger among obese persons than non-obese persons.[104]
- Obese children are more likely to have higher concentrations of 2,5-DCP in their urine, a metabolite of the pesticide found in mothballs (p-dichlorobenzene). This correlation was observed in data from the National Health and Nutrition Examination Survey (NHANES).[105]

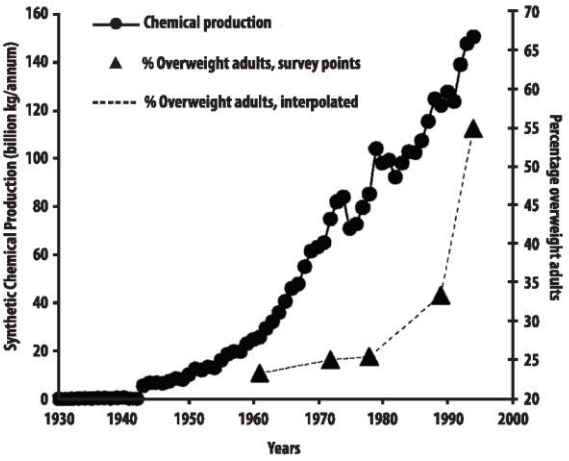
A number of specific genes have been identified as contributing to obesity, with several thought to specifically contribute to obesity in children. Such genes may play a role in regulating metabolic hormones.[106]

Scientists are now investigating the role of environmental factors (such as exposure to pesticides) in influencing the expression of such genes. Such "epigenetic" changes can include the expression of genes that are typically "silent," or inactivation of a gene that is normally active. Researchers are finding that some of these changes can be passed from one generation to the next (see sidebar).[107]

* Lindane, an organochlorine insecticide, is slated for global phaseout under the Stockholm Convention on Persistent Organic Pollutants. Agricultural uses were phased out in the U.S. in 2006; pharmaceutical uses (lice shampoos and scabies treatments) were phased out in California in 2001, but are still allowed in other states.

† Most organochlorine pesticides are now banned in the U.S., and many have been targeted for international phaseout under the Stockholm Convention. Rapid implementation of this treaty will reduce further exposure to these long lasting chemicals that continue to travel the globe on air and water currents.

Figure 7. Chemical Production & the Percentage of Overweight Adults in the U.S.



Researchers note that the obesity epidemic coincides with the increase in use of industrial chemicals, including pesticides, over the past 40 years. Source: Baillie-Hamilton, P.F. "Chemical toxins: a hypothesis to explain the global obesity epidemic." *J Altern Complement Med.* 2002 8: 185–192.

Mechanisms of Harm

Changing gene signals

Many environmental pollutants can strip or add chemical tags to DNA, locking the expression of genes on or off and changing how they function. These changes are called "epigenetic tags," and have been linked to various health effects including early puberty, disrupted ovarian function, death of sperm-forming cells and changes in metabolic rate.

Recent studies suggest that some chemicals can even override the genetic "reset button" that usually protects a developing fetus from such changes being passed from one generation to the next.

I-Fra5

Today, more than seven million children have asthma, up from just over two million 30 years ago.

Asthma epidemic affects more than seven million children

Asthma is a chronic disease of the pulmonary system that causes wheezing, breathlessness, chest tightness and coughing. The number of U.S. children with asthma today is much higher than it was 30 years ago, rising from 2.1 million in 1980 to 7.1 million in 2009.[108] Today, it is the most common chronic childhood disease in the U.S. (see Figure 8).

Asthma is the leading cause of hospital admission among urban children, with over 200,000 hospitalizations every year. Asthma is also the top cause of days lost from school, with more than 10.1 million school days missed every year.[109] Missed school days in turn negatively impact academic performance, such that children with severe asthma symptoms are more likely to suffer academically than children with milder symptoms.[110]

Asthma disproportionately affects people of color. Data from 2009 show that roughly one in six (17 percent) non-Hispanic black children had asthma in 2009, the highest rate among any racial/ethnic group. Overall, boys are more likely than girls to suffer from asthma (11.3 vs 7.9 percent) from birth through adolescence. As adults, women are more likely to be asthmatic than men.[111,*]

The Science

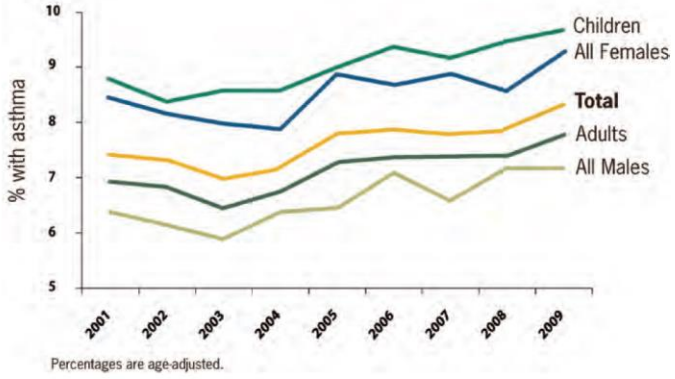
Many studies have explored the relative importance of common "respiratory irritants" in the home environment to triggering the onset of asthma, including cockroaches, dust mites, molds and air pollutants. Many pesticides are considered respiratory irritants,[†] and studies suggest that pesticide exposures may play a role in triggering asthma attacks, exacerbating symptoms, or heightening the overall risk of developing asthma.[112]

Pesticides may also play a role in increasing asthma incidence by affecting the body's immune system, triggering either hypersensitivity or suppression of the body's immune response. Allergic responses, for example, are a hypersensitivity of the immune system to an allergen in the environment.[113]

Numerous studies have documented the association of pesticides and asthma incidence for adults, and more recent studies have examined potential links to both asthma incidence and triggering or exacerbation of wheezing episodes among children.

- In a study of over 4,000 children from 12 southern California communities, exposure to pesticides in the first year of life significantly increased the risk of being diagnosed with asthma by age five.[114]
- A cross-sectional study of 3,291 Lebanese school children found a potential association between childhood asthma and parental occupational exposure to a range of current use pesticides.[115]
- In Spain, children diagnosed with asthma at age six had higher levels of cord serum DDE at birth than children without asthma. And in a study of 343 German children aged 7–10 years who had the DDT breakdown product

Figure 8: Asthma Prevelence by Age and Sex in U.S., 2001–2009



Percentages are age-adjusted.

Source Centers for Disease Control and Prevention, Vital Signs: Asthma in the U.S. See http://www.cdc.gov/VitalSigns/Asthma/index.html, viewed May 2012.

* In May 2012, the President's Task Force on Environmental Health and Safety Risks to Children released the *Coordinated Federal Action Plan to Reduce Racial and Ethnic Asthma Disparities*. The effort lays out a plan to address this crucial public health challenge during the next three to five years. See http://www.epa.gov/asthma/childrenstaskforce.

† See the *Recognition and Management of Pesticide Poisonings* page of EPA's National Pesticide Information Center site: http://npic.orst.edu/health/child.html

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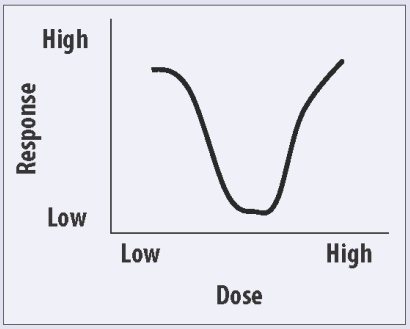
Rethinking "Safe"

Why the dose does not make the poison

Traditional toxicology relied for years on the mantra "the dose makes the poison." We now know that this statement is, in many cases, simply inaccurate. It assumes that the level of harm always increases as the level of exposure goes up (i.e., that every "dose response curve" follows a linear pattern). Assuming a higher dose is always more dangerous, policymakers often base regulations on a level below which no health risks is expected—a "safe" threshold. The reality, as scientists now understand, is quite different.

For some pesticides, the linkage between exposure and effect actually follows a U-shaped curve. In this scenario, a very low dose elicits a high level of "response" or health harm. At a higher dose that is along the bottom of the U, this same chemical elicits little or no response. Then at the highest doses, the effects increase again. For other pesticides, an inverted U–shaped curve can occur, where intermediate doses cause the greatest response, and testing at high doses can completely miss the effect.

Given these complex dose-response patterns, picking a threshold dose—below which exposure can always be considered "safe"—is simply not possible. Throw into the mix the dramatic differences in how sensitive individuals may be to chemical exposures, plus the vulnerabilities of children at particular times during development, and it quickly becomes clear that it is much more than the "dose" that determines how much harm a pesticide will cause.*



* Vandenberg, L., T. Colborn, T. Hayes, J. Heindel, D. Jacobs, D.H. Lee, et al. "Hormones and Endocrine-Disrupting Chemicals: Low-Dose Effects and Nonmonotonic Responses." *Endocrine Reviews*. March 2012 33(3): 378-455.

DDE present in their blood, the risk of having asthma was significantly higher.[116, *]

- Childhood exposure to organophosphate, carbamate and pyrethroid insecticides may trigger or exacerbate asthma symptoms among children by promoting bronchial constriction.[117]

Recognizing the rising prevalence of asthma among U.S. children, Dr. David Schwartz recently called on fellow researchers to focus more attention on the potential links between exposure to air pollutants and environmental contaminants like pesticides and childhood asthma.[118]

* These measurements were taken from blood serum and were thought to represent early life or prenatal exposures, but the actual route of exposure was not known.

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4 Critical Junctures

Children exposed just as they are most vulnerable

Children cannot make choices about their environment; it is up to adults to make the right decisions to ensure that they are protected. — Dr. Lynn R. Goldman

Environments we would like to consider "safe" often bring children into contact with pesticides and other chemicals that have been linked to health harms. Many chemicals pass across the placenta into the womb, where they become part of the first environment of a developing fetus. In the months after birth, infants begin to explore their new world, often testing new sights and smells by touching and bringing objects to their mouths. When harmful chemicals are present, they are often taken in.

The environments of toddlers and school-age children expand to include daycare centers, classrooms, playing fields and parks, all of which may offer risk of pesticide exposure. Residues on and in food—from breastmilk to the highchair to the school lunch tray—are also an important source of pesticides throughout childhood.

Many pesticides can pass across the placenta into the womb, where they become part of the first environment of a developing fetus.

Physiological systems undergo rapid development at various stages of childhood, in finely tuned processes often triggered and orchestrated by hormones. During this same period, children take in more food, water and air than adults pound-for-pound, and their biological systems are less able to process harmful contaminants than adults.

In short, the multiple pathways of pesticide exposure mean that in a given day, a child may absorb a wide range of potentially harmful chemicals just as their young bodies are at their most vulnerable.

Fetal pesticide exposures can have life-long effects

Exposure to pesticides has been clearly documented during one of a human organism's most vulnerable stages: fetal development.

Pesticides that have accumulated for years in an expectant mother's body—stored in blood and fatty tissues—can be mobilized during pregnancy and cross the placental barrier. A mother's exposures to pesticides during pregnancy add to this chemical mixture in the womb.[119]

Many studies have documented the pesticide load newborns bring with them into the world. Researchers in New York documented pesticides and their breakdown products in umbilical cord blood of more than 80 percent of newborn infants tested.[120] One 2001 study found metabolites of organophosphate pesticides in 100 percent of the cord blood samples taken.[121] A pilot study of amniotic fluid also found organophosphate metabolites, providing further evidence of fetal exposure.[122]

Pesticide residues from the food mothers eat during pregnancy have also been found in infants. A recent Canadian study showed that when pregnant women consumed soybeans, corn and potatoes that had been genetically modified for use with particular herbicides, metabolites of one of the herbicides showed up in cord blood of 100 percent of their babies.[123] *

Fetal development is almost entirely controlled by the expectant mother's hormones, acting at very low levels to trigger and control growth of the various systems of the body. Some chemicals—including many pesticides—mimic hormones and so interfere with natural developmental processes. This disruption of hormone function can lead to irreversible life-long effects including birth defects or learning disabilities in childhood, or adult onset cancer or infertility later in life (see sidebar, p. 17).[124]

Pesticide exposures common at home, daycare & school

Pesticides tend to be especially persistent in the indoor environment where sunlight, rain, soil microorganisms and high temperatures cannot degrade them, which means longer windows of exposure.

At home & in daycare facilities

Infants and toddlers have busy hands that often reach their mouths, and they commonly play on or near the floor—so

* The women in the study were in urban environments, and had no contact with the herbicides beyond residues on or in their food.

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Children as Farmworkers

Some children are exposed to pesticides as they work in agricultural fields. Specific rules vary from state to state, but federal law allows children under 12 to do field work outside of school hours on farms where their parents are employed.*

Age restrictions for hazardous work such as applying pesticides are more lenient in the agriculture sector, and age restrictions simply do not apply for children working on farms owned or operated by a parent or guardian.

Documenting the exact number of child workers in U.S. agriculture is difficult, and estimates vary widely. A Human Rights Watch report published in 2000 put the number somewhere between 300,000 and 800,000.† The nonprofit group Toxic Free North Carolina recently documented the experience and voices of young farmworkers facing pesticide exposure in the field; the stories can be viewed at www.panna.org/youngfarmworkers.

* U.S. Dept. of Labor. "Child Labor Requirements in Agricultural Occupations Under the Fair Labor Standards Act." June 2007. See http://www.dol.gov/whd/regs/compliance/childlabor102.htm.

† Human Rights Watch. *Fingers to the Bone: United States Failure to Protect Child Farmworkers.* Washington: Human Rights Watch, 2000.

National Center for Farmworker Health. *Child Labor.* Buda, Texas. 2009. See www.ncfh.org/docs/fs-Child%20Labor.pdf

Davis, S. and J.B. Leonard, *The Ones the Law Forgot: Children Working in Agriculture,* Farmworker Justice, Washington DC. 2000.

when pesticides are used in homes or daycare facilities, exposure is a near certainty. Inhaling spray droplets, vapors or pesticide-contaminated dust from indoor use of pesticide products is one of the primary routes of exposure for many U.S. children. Pesticides used to control ticks and fleas on pets are another important source of children's exposure.[125]

One Massachusetts study found residues of DDT in house dust many decades after use of the chemical had been discontinued.[126] Even pesticides that are relatively short-lived in the environment are more persistent indoors; one study found the semi-volatile insecticide chlorpyrifos to be longer lasting than expected in closed apartments, detectable for more than two weeks on rugs, furniture, soft toys and pillows.[127] Pesticide vapors often settle after application indoors, so levels tend to be highest in the infant breathing zone.[128]

Exposure from home lawns and gardens or outdoor play areas at daycare centers can also be significant. Children often roll and play on lawns and sit or lie on bare soil, and toddlers are known to put dirt directly into their mouths.[129] If pesticides have been used in these areas, the likelihood of ingestion or inhalation is high.

In rural communities, the risk may be compounded by drift from nearby agricultural fields. A study conducted in Washington State found residues of several agricultural pesticides—including chlorpyrifos and ethyl parathion—in outdoor play areas.[130] Air monitoring studies using PAN's Drift Catcher in

Evidence shows that when pesticides are used at home, on pets or in daycare centers, children's exposure is a near certainty.

California and Minnesota have documented a range of agricultural pesticides in backyards and play areas as well.[131, 132]

Rural infants and toddlers also face potential exposure from drift directly into their homes, and from pesticide contamination of water supplies. Water sampling results from Illinois, Nebraska, Iowa and Minnesota detected the common herbicide atrazine at levels above those linked to low birth weight.[133] Young children in farmworker families face additional exposure from residues carried into the home on the bodies and work clothes of working family members.[134]

At school & on playgrounds

Pesticides used in school buildings can settle on desks, books, counters and walls. When children touch contaminated surfaces, they may absorb chemical residues that can remain in the school environment for days. Herbicides used to keep playing fields free of weeds may be picked up on children's hands, bodies, clothes and tennis shoes, or drift into classrooms after application.

According to one recent national review, of the 40 pesticides most commonly used in schools, 28 are probable or possible carcinogens, 26 have been shown to cause reproductive effects, 26 damage the nervous system, and 13 have been linked to birth defects.[135]

In rural areas, pesticides often drift into schoolyards during and after spraying on nearby fields. Community air monitoring studies across the country using the Drift Catcher device have documented pesticides in or near school grounds in agricultural communities,[136] and incidents of pesticide poisonings in schools are not uncommon. For example:

- In Florida, high school students used a Drift Catcher to measure the pesticides endosulfan, diazinon and trifluralin* drifting into the school from nearby cabbage fields.[137]

* Endosulfan is currently being phased out in the U.S., and also globally under the Stockholm Convention on Persistent Organic Pollutants. See http://www.epa.gov/oppsrrd1/reregistration/endosulfan/endosulfan-cancl-fs.html.

- Schoolchildren in Strathmore, CA were exposed to pesticides sprayed in a neighboring field, feeling dizzy and falling sick in November, 2007.[138]
- Seven children were hospitalized and a total of 11 people sickened in Kahuku, Hawaii, in 2007, when fumes from an organophosphate insecticide drifted over the school from a nearby sod farm.[139]

Pesticide use on playing fields has raised concerns among families and environmental health advocates nationwide. The National Coalition for Pesticide-Free Lawns notes that "the common, everyday practices used to maintain our children's playing fields are unintentionally and unnecessarily exposing them to carcinogens, asthmagens, and developmental toxins," and calls for a shift to organic turf management on playing fields across the country.[140]

Pesticide residues, from breastmilk to the school lunch tray

Pesticide residues in food and drink are a key source of constant, low-level exposure to mixtures of pesticides throughout childhood.

Nature's Finest, Compromised

Pesticides in breastmilk

Human breastmilk is without doubt the best source of nutrition for infants, offering the perfect combination of fats, carbohydrates and proteins for developing babies. It also offers protection from infection, increases resistance to chronic disease and contributes to the emotional wellbeing of both infant and mother.

But decades of breastmilk sampling also leaves no doubt that around the world, nature's perfect food for infants is compromised by pesticides and other toxic chemicals. Today there is no corner of the planet where human breastmilk remains pure. The chemicals found in a mother's milk represent a combination of long-lasting pesticides and industrial pollutants that have accumulated over a lifetime (many of which the body tends to store in fatty tissues), and shorter-lived chemicals that a woman is exposed to during pregnancy and breastfeeding.

This chemical burden is transferred to nursing infants just as their bodies are most vulnerable to chemical harms. The good news is that analysis of decades of banked breastmilk in Sweden shows that bans on specific chemicals can result in rapid and dramatic decreases in the levels of some of those compounds in human milk.*

* Norén K., D. Meironyté. "Certain organochlorine and organobromine contaminants in Swedish human milk in perspective of past 20-30 years." *Chemosphere*. May-Jun 2000;40(9-11):1111-23. See http://www.ncbi.nlm.nih.gov/pubmed/10739053.

Natural Resources Defense Council. "Healthy Milk, Healthy Baby: Chemical Pollution and Mother's Milk." See www.nrdc.org/breastmilk.

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Children take in more food, water and air than adults pound-for-pound, just as their bodies are less able to process harmful contaminants.

Studies from around the world have documented pesticides in human breastmilk, though experts agree it remains the best source of nutrition for infants (see sidebar). Baby foods and fruit juices consumed by infants and toddlers tend to be highly processed, which can sometimes concentrate pesticide residues existing on the fresh produce.[141] U.S. researchers measuring pesticides in baby foods found low-level residues of many pesticides, including eight known to be toxic to the nervous system, five that disrupt hormones and eight that are potential carcinogens.[142]

Food consumed by school-age children can also contain pesticide residues. Researchers examining the diets of urban children found that 14 percent of the foods sampled contained at least one organophosphate pesticide. In total, 11 different organophosphates and three pyrethroids were found.[143] USDA residue sampling of produce commonly eaten by children—such as carrots, apples and peaches—found metabolites of dozens of different pesticides in each of these foods over the course of their testing (26 found in carrots, 42 in apples and 62 in peaches).*

Pesticides directly measured in children's bodies also tell a story about the importance of dietary exposure. Researchers compared levels of organophosphate metabolites in the urine of children who were eating organic fruit, vegetables and juice with children eating conventionally farmed produce. They found that those with more organic diets had metabolite levels six times lower than those with conventional diets.[144] Other studies show that when families switched to organic fruits and vegetables, metabolites of the insecticides chlorpyrifos and malathion fell quickly to undetectable levels.[145]

The widespread presence of pesticide metabolites in children's bodies,[146] combined with studies showing that changes in these levels are linked to changes in dietary exposure, make a very clear case that pesticide residues in food are a consistent source of children's daily intake of a mixture of pesticides.

* These numbers do not necessarily reflect residues on a single sample. See USDA data at www.whatsonmyfood.org.

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Why children are particularly vulnerable

So what do all of these well-documented pesticide exposure pathways mean for children's health?

In their first six months of life, children take in roughly 15 times more water than the average adult per pound of body weight.[147] Children also inhale more air. Up to around age 12, a child's breathing rate is roughly twice that of an adult, which means a child will inhale roughly double the dose of a pesticide in the air from spray drift or household use.[148]

Exposure to pesticides occurs largely through touching, inhaling or ingesting. For each of these routes, children are much more likely to absorb what they come into contact with than adults. The skin of infants and young children, for example, is particularly permeable, and the skin surface area relative to body weight is much greater in children than adults.[149] The lung surface area relative to rate of breathing is also higher among children,[150] and absorption levels in the gastrointestinal tract are also greater (especially for alkaline pesticides), as adult levels of gastric acid are not reached until a child is about two years old.[151]

As noted above, the brain and nervous system are especially vulnerable during fetal development and for the first six months of life. During this period the blood-brain barrier,* which provides the adult nervous system some protection from toxic substances, is not yet fully developed.[152]

Finally, young bodies are less equipped to process and excrete harmful chemicals as the liver and kidneys—the body's primary detoxifying organs—are not yet fully developed. Levels of enzymes that help the body process chemicals are also not yet at full strength (see sidebar). Genetic variations lead to tremendous range in the production of these protective enzymes—with some newborns as much as 164 times more vulnerable to chlorpyrifos than less sensitive adults.[153]

According to researchers, this finding alone means that most, if not all infants and toddlers—as well as a subpopulation of adults—are much more likely to have adverse health effects from organophosphate exposure. Policies that don't account for this variability fail to protect the most vulnerable, leaving many children in harm's way.

* The blood-brain barrier is made up of high-density cells that protect the brain from potentially harmful substances circulating in the bloodstream.

Mechanisms of Harm

When enzymes don't detoxify

Enzymes are proteins that catalyze reactions on a molecular level, and there are many that occur naturally in the human body. Without enzymes to catalyze reactions, some of the chemical reactions that make up the normal functioning of our body could take much longer, or not happen at all.

One key human enzyme, known as paraoxonase 1 (or "PON1"), catalyzes the metabolic process that renders organophosphate pesticides and other compounds less harmful to our systems. Researchers say infants have very low levels of this enzyme up to age two, and children don't reach adult PON1 levels until about age seven.* This suggests that children are less protected from harmful contaminants by enzyme activity, and newborns may be especially vulnerable.

There is also tremendous natural variability in the level and effectiveness of the PON1 enzyme, which means some individuals are much more susceptible to health harms of organophosphate pesticides and other contaminants.†

* Huen K., K. Harley, A. Bradman, B. Eskenazi, N. Holland. "Longitudinal changes in PON1 enzymatic activities in Mexican-American mothers and children with different genotypes and haplotypes." *Toxicol Appl Pharmacol.* 2010. 244(2):181-9. See http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2846980/?tool=pubmed

† Holland, N., C. Furlong, M. Bastaki, R. Richter, A. Bradman, K. Huen, et al. "Paraoxonase Polymorphisms, Haplotypes, and Enzyme Activity in Latino Mothers and Newborns." *Environ Health Persp.* July 2006 114 (7): 985–991. See http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1513322/.

The human body undergoes rapid growth and development throughout childhood, with many processes vulnerable to disruption from pesticides and other chemicals.

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5 Case Studies
Communities win protections for children

What we love we must protect. — Sandra Steingraber

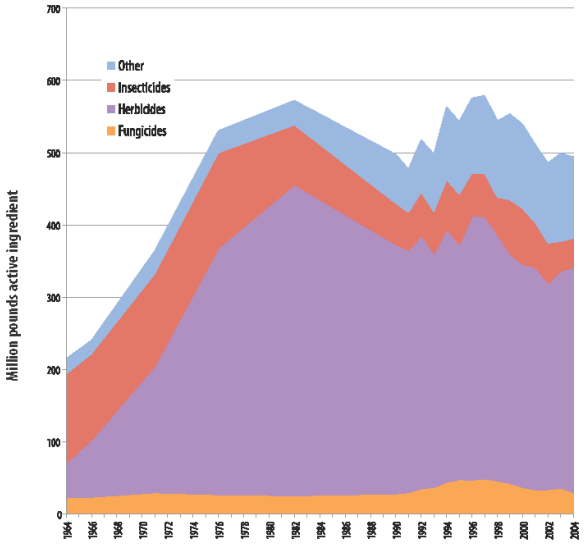
Since the middle of the last century, the overall increase in pesticide use in this country has been steady and dramatic. As documented above, these pesticides are a critical contributor to many of the chronic diseases and disorders now affecting our children.

To address the unique vulnerability of children, concerned communities, public health officials and advocates are beginning to put policies in place at the state and local level that reduce the use of harmful pesticides. In this chapter we provide a brief overview of U.S. pesticide use patterns and trends, and highlight on-the-ground stories of successful efforts to protect children from exposure in their early environments.

Pesticide use now 1.1 billion pounds yearly

Since 1945, use of herbicides, insecticides and other pesticides has grown from less than 200 million to more than 1.1 billion pounds per year, with well over 1,000 chemicals registered and formulated into more than 20,000 pesticide products (see Figure 9). This does not include pesticides used as wood preservatives or specialty biocides (in plastics and paints, for example). If these products are included, the number jumps to more than five billion pounds annually.[154, 155, 156]

Figure 9: Pesticide Use on Major Crops, 1964–2004



Source: "Land and Farm Resources: AREI, 2006 Edition," USDA Economic Research Service

Pesticide use in agriculture

The majority of pesticides are used in agricultural fields, with weed-killing herbicides being the highest by volume. Soil fumigants, which are injected as a gas into soil before planting to kill weeds, insects and fungi, are used at particularly high volumes and have a tendency to drift after application. Use of organophosphate insecticides, which gained widespread use in the 1980s as replacement chemicals for long-lasting organochlorine pesticides (such as DDT, chlordane and aldrin) has gradually declined in recent years.

In part to address growing concerns about organophosphate toxicity, a group of insecticides called pyrethroids were marketed as "safer" and gained widespread use in the 1990s, and use has grown rapidly. According to the American Chemical Society, use of pyrethroids in California (agricultural, structural and landscape maintenance applications) almost tripled from 1992 to 2006.[157] Recent research suggests that pyrethroids may be more harmful to humans than originally believed, acting as developmental neurotoxicants, endocrine disruptors and carcinogens.[158, *]

Another class of pesticides now in widespread and rapidly rising use is neonicotinoids. Most neonicotinoids show much lower toxicity in mammals than insects, but emerging science demonstrates that many may also have neurodevelopmental effects, and some are considered likely carcinogens by EPA.[159] These pesticides are considered 'systemic,' which means they are often applied at the root (as seed coating or drench) and are then taken up through the plant's vascular system. Systemic pesticides on food cannot be washed off.

Neonicotinoid pesticides have been linked with honey bee colony collapse disorder and bee kills, and several products have been banned in European countries for this reason. One neonicotinoid, imidacloprid, is now one of the most widely used insecticides in the world.[160]

* Ten years' worth of adverse-reaction reports (filed by manufacturers) show that pyrethrins and pyrethroids together accounted for more than 26 percent of all fatal, "major," and "moderate" human pesticide poisoning incidents in the U.S. in 2007, up from 15 percent in 1998. See http://apps.cdpr.ca.gov/calpiq/calpiq_input.cfm to see the primary data; for data analysis, see http://www.iwatchnews.org/environment/health-and-safety/perils-new-pesticides.

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To protect children's health, several states have put policies in place prohibiting the use of pesticides on playing fields and playgrounds.

Pesticide use at home

While 80 percent of all pesticides are applied in agricultural fields, use in homes, gardens, playgrounds, schools, hospitals and other buildings is also significant—and as noted above, such uses pose a particular risk to children's health.

In 2007, an estimated 78 million pounds of pesticides (measured by active ingredient) were applied in homes and gardens across the country, with the herbicides 2,4-D and glyphosate (RoundUp) topping the list.[161] The household pesticide product industry has an estimated annual net worth of $1.4 billion; according to EPA, more than 78 million households—roughly 74 percent of all households in the U.S.—report using pesticides at home (see Table 5).[162]

Many home-use insecticides contain pyrethroids, and the chemicals are used extensively in homes where the potential for exposure to children is very high. Researchers from Emory University and the CDC found that even children fed an exclusively organic diet had pyrethroid metabolites in their systems after their parents had used pyrethroid insecticides in their homes.[163]

Neonicotinoid products are widely used in pet products to control fleas and ticks—another use which poses particularly high exposure risks for children.[164]

Safer pest control at schools & daycare centers

More than 3,000 pesticide products are currently approved for use in schools;[165] yet current national pesticide rules do not address the use of pesticides in and around schools or daycare centers. The federal School Environmental Protection Act (SEPA) was first introduced in November 1999 in an attempt to address this oversight—and it continues to be debated in Congress today.

In the non-profit sector, the national Children's Environmental Health Network (CEHN) moved to fill this gap by creating the Eco-Healthy Child Care (EHCC) program to provide tools that facilities need to create environmentally healthy spaces for children. Today, the program endorses over 1600 "Eco-Healthy" daycare facilities across the country and provides this list to parents online.*

Meanwhile, several states are moving forward with policies designed to protect children from pesticides in these early environments.

- In 2005 Connecticut lawmakers prohibited use of pesticides on K–8 lawns and playing fields; in 2009, the law was extended to daycare center grounds. Through this policy, schools have successfully implemented organic turf programs in various municipalities.[166]
- New York followed suit in 2010, signing the Child Safe Playing Fields Act into law to ban the cosmetic use of pesticides on playgrounds and sports fields at schools (including high schools) and daycare centers.[167]

Table 4: Pesticide Usage in All Market Sectors, 2007

Pesticide Class	Active Ingredient
Herbicides	531 million lbs
Insecticides	93 million lbs
Fungicides	70 million lbs
Fumigants/Nematicides	133 million lbs
Other	30 million lbs
Total	*857 million lbs*

Herbicides are the most commonly used type of pesticide in the U.S., with 531 million pounds of active ingredient applied in 2007. Source: *Pesticide Industry Sales & Usage, 2006 and 2007 Market Estimates*, U.S. EPA, Washington, DC Feb 2011. See www.epa.gov/opp00001/pestsales/07pestsales/market_estimates2007.pdf.

Table 5: Households Using Pesticides

Pesticide Type	# Households
Insecticides	59 million
Fungicides	14 million
Herbicides	41 million
Repellents	53 million
Disinfectants	59 million
Any pesticides	78 million

According to EPA, more than 78 million households—roughly 74 percent of all households in the U.S.—use pesticides at home. Source: EPA estimates based on the 1992 EPA National Home and Garden Survey and 2000 U.S. Census Bureau population estimates (www.quickfacts.census.gov/qfd/states).

* See http://www.cehn.org/ehcc for more information about this program.

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At What Cost?

Economic impacts of health harms

The impact on families of caring for—and sometimes losing—a child in ill health cannot be reflected in monetary terms. Nor can the incalculable costs of lowered IQ, lost opportunities and social alienation that can accompany developmental effects. But actual costs of providing medical care for a child with a chronic condition or illness can be calculated, and according to public health officials, health care costs for childhood diseases are significant. Here are some examples:

ADHD: Researchers estimate annual ADHD health care costs in the U.S. to be between $36 and $52 billion (in 2005 dollars).*

Autism: One analyst at the Harvard School of Public Health estimates that it costs $3.2 million to care for an autistic person over their lifetime.†

Cancer: The total costs per case of childhood cancer—from treatment, to laboratory costs to lost parental wages—is an estimated $623,000 per year.‡ This translates into a society-wide cost of roughly $6.5 billion annually for the 10,400 newly diagnosed cases each year.

Asthma: Families nationwide pay a combined total of $14.7 billion dollars a year on medical care costs of asthma.§,¶ The combined direct and indirect costs of asthma to the U.S. economy were an estimated $19.7 billion in 2007.**

Society-wide costs also include higher educational costs for public school systems to meet the needs of children with neurodevelopmental disorders, missed school days (and thus less well-educated students) caused by asthma, and the general productivity losses due to time parents and caregivers take off from work to care for an ill child.

The numbers above do not take into consideration the loss to individuals, families and society as a whole of children not reaching their full physical or intellectual potential. The overall impact of lost creativity, productivity, problem-solving skills and civic engagement, along with higher rates of social alienation and disruption, cannot be overstated.

* Pelham W., E.M. Foster and J.A Robb. "The Economic Impact of Attention Deficit/Hyperactivity Disorder in Children and Adolescents" *Journal of Pediatric Psychology*. 2007. See http://jpepsy.oxfordjournals.org/content/32/6/711.full.pdf+html.

Centers for Disease Control and Prevention. Attention-Deficity/Hyperactivity Disorder (ADHD): Data and Statistics in the United States. See http://www.cdc.gov/ncbddd/adhd/data.html.

† Ganz, Michael "The Costs of Autism," in *Understanding Autism: From Basic Neuroscience to Treatment* (CRC Press, 2006). See http://www.hsph.harvard.edu/news/press-releases/2006-releases/press04252006.html

‡ Landrigan, P.J., C.B. Schechter, J.M. Lipton, M.C. Fahs and J. Schwartz. "Environmental pollutants and disease in American children: estimates of morbidity, mortality, and costs for lead poisoning, asthma, cancer, and developmental disabilities." *Environ. Health Perspect.* 2002; 110, 721–728.

§ EPA, Children's Heath Protection. "Fast Facts on Children's Health." See http://yosemite.epa.gov/ochp/ochpweb.nsf/content/fastfacts.htm. Viewed June 2012.

¶ Centers for Disease Control and Prevention. *Vital Signs: Asthma in the U.S.* See http://www.cdc.gov/VitalSigns/Asthma/Index.html. Viewed May 2012.

** EPA, Children's Heath Protection. "Fast Facts on Children's Health." See http://yosemite.epa.gov/ochp/ochpweb.nsf/content/fastfacts.htm. Viewed June 2012.

- Many school districts in California have significantly reduced pesticide use after a 2000 state law required pesticide reporting and provided incentives for adoption of IPM. School districts in Los Angeles, San Francisco, Santa Barbara and Palo Alto have made particular progress.[168]
- In 2001, California legislators passed a law (AB 947) allowing county agricultural commissioners to restrict pesticide spraying near sensitive sites, including schools and daycare facilities. Under this provision, communities in Tulare County won new rules in 2008 requiring a quarter mile buffer zone banning the aerial application of restricted-use pesticides around schools when they are in session or due to be in session within 24 hours, occupied farm labor camps and residential areas.[169] Kern, Stanislaus, Merced and Fresno counties enacted similar rules in subsequent years.

Pesticide-free school lunches

Currently, neither state nor national policies are in place to reduce pesticide residues in school lunches. But many communities across the country are leading the way to provide children with nutritious school lunches including fresh (sometimes locally produced) fruits and vegetables free from pesticides.

- In Washington state, the Olympia School District has implemented an Organic Choices Salad Bar (25 percent of the produce is purchased directly from local farms and 50 percent of the salad bar is organic), and the Orcas Island Farm-to-Cafeteria Program integrates produce from local, organic farmers and a school garden, and hosts student chef competitions.
- In Minnesota, the White Earth Land Recovery Project added a farm-to-school component in the 2007–2008 school year to their Mino-miijim (Good Food) Program to help reach their goal of food sovereignty on the reservation and promote access to fresh, local and organic ingredients.[170]
- Berkeley, California's Edible Schoolyard (ESY) Project began as a one-acre "interactive classroom" providing primarily organic, fresh fruits and vegetables for student's meals at King Middle School. It has grown into an online initiative building and sharing a food curriculum, and it has inspired similar programs across the country.[171]

Many of these programs are part of the National Farm to School Network (NFSN), which connects K–12 schools across the country with local farms in an attempt to serve healthy meals at school lunch tables while supporting local, often organic, farmers.[172]

Parks & playgrounds without pesticides

Communities across the country are choosing to manage public parks and playgrounds without harmful pesticides. In the Pacific Northwest, 17 cities are phasing out pesticide use with the creation of 85 pesticide-free parks and playgrounds, building momentum for strong policies at the local level despite legislative hurdles (see sidebar on following page).[173]

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Farm-to-school programs across the country are providing children with fresh, pesticide-free fruits and vegetables in school cafeterias.

Seattle in particular has emerged as a pioneer of pesticide-free cities, dramatically reducing its pesticide use in parks by an estimated 80 percent since the 1970s. In 1999, they adopted a pesticide reduction strategy for all city departments and designated 14 pesticide-free parks.[174] The program is now expanding to 22 parks and 50 acres distributed throughout the city.[175]

On the other side of the country, New Jersey legislators unanimously voted in 2011 to pass "The Child Safe Playing Field Act" prohibiting pesticide use on all municipal, county and state playgrounds and playing fields, as well as daycare and school grounds.[176]

Many other communities across the country are following this trend. From a pilot program in Lawrence, Kansas to innovative communities throughout Oregon, California and Colorado, cities are creating pesticide-free parks and playgrounds for children to safely enjoy.

The Pre-emption Law Hurdle & Canada's Local Pesticide Bans

As of 2010, 40 states had pre-emption laws specifically prohibiting municipalities from passing local pesticide ordinances that are stricter than state policy. These laws, which are strongly supported by the pesticide industry, limit the ability of city or county governments to ban or restrict pesticide use.

Such pre-emption laws do not exist in Canada. Over the past 20 years, dozens of Canadian cities have used their local authority to outlaw the application of home and garden pesticides for "cosmetic" purposes such as lawn care.

In 1991, the municipal council of Hudson, Canada, enacted the first ban on cosmetic uses. Similar local bans were adopted across the country, and today more than 170 Canadian cities and towns have passed full or partial bans on pesticide use, and the provinces of Quebec, Nova Scotia and Ontario have enacted comprehensive cosmetic pesticide bans. According to Canadian community activists, more than 22 million Canadians (65% of the population) are now protected from exposure to cosmetic pesticides.*

* Pesticide Free B.C. "Pesticide Bylaw Communities Across Canada." See http://www.pesticidefreebc.org/index.php?option=com_content&view=category&layout=blog&id=53&Itemid=72. Viewed July 2012.

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6 Investing in a Healthier Future

A solid start for our children must be a national priority

Those who argue that societies cannot afford to make immediate investments in reducing environmental pollution fail to appreciate that there are some forms of harm that cannot be repaired. — Deborah Axelrod, Devra Lee Davis & Lovell A. Jones

As a nation, we value the wellbeing of our children. In addition to our natural urge to protect what we love, we know that at a societal level their success is key to a vibrant, secure future. Poll after poll shows more than 80 percent of Americans consider healthy children a top priority.[177] We must line up our practice and policies with these values.

Our current use of over a billion pounds of pesticides every year puts their wellbeing at risk and, as the science demonstrates, can derail brain and body development and rob them of their full potential.

If there were no other way to control pests, it would be one kind of choice: weighing one set of needed benefits against known and evolving harms. But given the fact that there are many proven ways to control pests without use of harmful chemicals, the choice is quite clear. It is time to have policies in place that better protect our children (see sidebar).

The National Research Council recommended swift action to protect children from pesticides nearly 20 years ago, and it has been 50 years since Rachel Carson sounded the initial alarm about the health harms pesticides can cause. What is standing in the way?

Pesticide industry well served by current policies

Our current system of industrial agriculture and pest control relies on chemical inputs sold by a handful of corporations. These multinational corporations wield tremendous control over the system, from setting research agendas[178] to financing, crop selection and inputs throughout the production and distribution chain.

Not surprisingly, these same corporations also hold significant sway in the policy arena, investing millions of dollars every year to influence voters, lawmakers and regulators at both the state and federal level to protect the market for pesticides.[179]

The result is agriculture, food and pest control systems that serve the interests of these corporations well. It does not, however, serve farmers, who have lost day-to-day control of their operations and are putting themselves and their families in harm's way. Farmworker interests are not served, as workers are continuously exposed to chemicals known to harm human health.

And the health of children across the country is compromised by exposure to pesticides used to control pests in agriculture and where they live, learn and play.

In short, the system is broken.

Prioritizing children's health requires real change

The best way to protect children from the harms of pesticides is to dramatically reduce the volume used nationwide. This would not only limit children's exposure during their most vulnerable years, it would also lower pesticide levels in the bodies of men and women of childbearing age—protecting current and future generations in one fell swoop. Those pesticides most harmful to children should be first on the list.

This is not a small change, and not a recommendation made lightly. Yet the science tells us the problem is serious and urgent, and that viable and safer alternatives are available. If we stay on our current path, our children will not reach their full potential as we continue to compromise their health.

U.S. Pesticide Rules

Overdue for overhaul?

A little over 100 years ago, Congress enacted our first national pesticide law. The 1910 Insecticide Act put labeling guidelines in place to protect farmers from "hucksters" selling ineffective, misbranded or adulterated pesticide products.

To this day, we control pesticides through a system of registration and labeling. The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), passed by Congress in 1947, is our primary national pesticide law. It has been updated several times in the last 65 years as the health and environmental effects of pesticides came into light, most significantly in 1972 and again in 1996.

It remains, however, a system of registration and labeling, and as such has significant shortcomings. Our current pesticide rules:

- Do not allow for quick response to emerging science;
- Do not assess risk based on real-world exposures;
- Rely heavily on corporate safety data that is not peer-reviewed; and
- Do not encourage the safest form of pest control.

In addition, enforcement of any guidelines or restrictions specified on product labels is relegated to state governments that rarely have adequate resources for the job. Overall, our current rules do not provide adequate tools to protect children from the harms of pesticide exposure.

Informed household food choices can help protect families and grow the market for food that is produced without harmful pesticides—encouraging more farmers to make this shift. And reducing household use of pesticides can provide immediate and long lasting benefits to children's health.* But the burden of protecting children from dangerous chemicals cannot rest solely with individual families. Policy change is required.

Recommendations: Effective policies urgently needed

To protect our children from the health harms of pesticides, policymakers must have much more effective tools. We believe such tools are most urgently needed as decisions are made about these three questions:

- Which pesticides are used in agriculture?
- Which pesticides are used in places children live, learn and play?
- How are farmers supported as they reduce reliance on pesticides?

We recommend the following policy changes in these three arenas:

1. Prevent the pesticide industry from selling agricultural products that can harm children's health

Given the wide-ranging susceptibility of children to pesticide exposures, plus the potential impacts on children from extremely low doses of toxic chemicals, the current approach to assessing and controlling risks of agricultural pesticides does not adequately protect our children.

Decisionmakers must have tools to remove an agricultural pesticide from the market quickly or deny a newly proposed pesticide market access when science suggests it can harm children's developing minds or bodies and there is evidence that children are likely to be exposed. Specifically, we recommend that rulemakers should:

- *Take swift action on existing pesticides:* If studies find a pesticide to be a neurodevelopmental or reproductive toxicant, endocrine disruptor or human carcinogen—*and* it has been measured in humans, in schools or homes, or as residues on food or in drinking water—EPA should target the pesticide for rapid phaseout, triggering USDA resources to assist rapid farmer transitions to safer pest control methods.†
- *Block harmful new pesticides:* EPA should not approve any new pesticide that scientific studies suggest is a neurodevelopmental or reproductive toxicant, endocrine disruptor or human carcinogen—including short-term "conditional" registrations.
- *Prevent harmful low-level exposures:* EPA should act on existing evidence that exposures to endocrine disrupting pesticides pose a particular danger to developing children;

* In addition to choosing non-toxic approaches to pest control (see PAN's Homes, Pets & Gardens online resource at http://www.panna.org/your-health/home-pets-garden), see also the National Pesticide Information Center's page on Pesticides and Children for suggestions on reducing children's exposure in the home: http://npic.orst.edu/health/child.html.

† See, for example, criteria and process for developing the "chemicals of high concern" list in Maine. http://www.maine.gov/dep/safechem/highconcern/chemicals.htm

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The best way to protect children from the harms of pesticides is to dramatically reduce the volume used nationwide.

the long-delayed endocrine disruptor screening program (EDSP) should be swiftly implemented. At the current rate, it will be 2017 before the first set of *only 58 chemicals* are screened.

The insecticide chlorpyrifos provides a clear example of the startling flaws in our regulatory system. Over 10 million pounds of the pesticide are still applied in agricultural

When Is There Enough Evidence to Act?

Scientific studies often identify a "link" or "association" between exposure to a particular pesticide and a specific health harm—but individual studies rarely demonstrate definitive causation. Epidemiological studies often lack statistical power, and case control and animal studies may miss key variables such as exposure timing.

A "weight of the evidence" approach recognizes that a body of scientific work will contain conflicting studies, but holds that when a number of well designed, robust studies come to similar conclusions, the findings should be considered valid.*

When such findings involve widespread, significant and irreversible health harms to our children, the bar for taking action should not be high. When credible evidence of harm emerges, a pesticide product should immediately be taken off the market until its manufacturer can prove its safety. Put simply, it is time the burden of proof shifted to the pesticide corporations, rather than regulators—and the public—as it currently stands.

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Investing in farmers who grow food without relying on chemicals that harm children's health must be a national priority.

fields every year, more than a decade after household uses were withdrawn because of *clear dangers to children's developing brains.** Yet children across the country continue to be exposed—in rural schools and communities, and by eating foods that have been treated with the neurotoxic chemical.

2. Protect children where they live, learn & play

Policymakers need strong tools to protect children from exposure to pesticides where they live, learn and play. Such protections will help keep developing bodies and minds healthy during the years they are most vulnerable to harm from chemical exposures.

We recommend rapid implementation of the following measures:

- *Kid-safe homes, daycares & schools:* EPA should withdraw approval of existing pesticide products and not approve new pesticides for use in homes, daycare centers or schools when scientific evidence indicates the chemicals are possible neurodevelopment or reproductive toxicants, endocrine disruptors or human carcinogens.
- *Safer parks & playgrounds:* State and local officials should enact policies requiring that all public playgrounds, playing fields and parks be managed without using pesticides that studies show are harmful to children's health.
- *Protective buffer zones:* State legislators should establish—or give local governments authority to establish—protective pesticide-free buffer zones around schools, daycare centers and residential neighborhoods in agricultural areas.
- *Healthier school lunches:* Local school districts, state agencies and USDA's Farm-to-school program should provide schools with incentives to procure fresh, local fruits and vegetables that have been grown without pesticides that studies show are harmful to children's health.

3. Invest in farmers stepping off the pesticide treadmill

Investing in farmers who grow food without relying on chemicals that harm children's health must be a national priority. Specifically:

- *Corral resources for farmers:* Federal and state officials should mobilize and coordinate existing resources to help farmers adopt well-known, effective pest management strategies that reduce reliance on pesticides. USDA, EPA and many state agencies and universities have important programs—research, outreach and education—with this stated aim that could be ramped up in complementary ways.
- *Increase investment in innovative farming:* Congress should authorize significant funding for programs supporting farmers' adoption of sustainable practices that reduce use of harmful pesticides. Existing programs receive a small fraction of the funding supplied to programs serving conventional growers.
- *Set use reduction goals:* EPA and USDA should set specific and aggressive national pesticide use reduction goals, focusing first on pesticides studies show to be harmful to children.† To track progress toward this goal, farmers should work with applicators and pest control advisors to report their pesticide use to a nationally searchable database.‡
- *Source for children's health:* Food distributors should require that their suppliers limit use of pesticides that harm children's health.

Effective agroecological methods exist for production of all major crops—but these approaches are often knowledge-intensive, requiring significant training as well as real changes in farm operation.§ Growers need direct support to make the shift away from pesticide reliance, including provision of hands-on field training and technical advice from independent experts as well as incentives to invest in agroecological practices.

These proposals are all commonsense measures in the face of clear evidence that our children's wellbeing is at risk. It's time to muster the political will and prioritize the health of our children, grandchildren and future generations.

* Chlorpyrifos was phased out for household use after studies clearly indicated that exposed children had smaller head circumference, a known indicator of reduced cognitive function.

† See Appendix B.

‡ Pesticide use reporting is already in place in California; lessons learned from implementation of this program (established in 1990) should inform and enable rapid adoption of a federal use reporting system.

§ Agroecological practices are based on the application of intricate place-based knowledge of soil/plant/animal interactions designed to prevent or minimize pest problems. Farmers are successfully using such practices in virtually every crop now grown in the U.S.

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Appendix A

More Science: Key study descriptions

Our intention in undertaking this review was not to conduct a comprehensive evaluation of the evidence. The body of scientific literature exploring how pesticides affect children's health is wide, deep and decades long.

Our goal is to provide a snapshot of recent findings, coming fast and furious in the just the past few years, that—taken together—provide compelling reason for concern about the impact of pesticides on our children's health.

In the report itself we highlight a few of the key findings for each health effect, focusing on studies that were particularly compelling, and/or represented other studies we reviewed with similar findings. We simplified descriptions of each study to provide a basic sense of how the research was conducted and what researchers found. Here in Appendix A we provide a bit more detail on some of the key studies described above, as well as additional studies. Study descriptions are organized by health effect, and alphabetically by author within each category.

Brain & nervous system harms (reduced cognitive function, autism, ADHD)

Bouchard M.F., D.C. Bellinger, R.O. Wright and M.G. Weisskopf."Attention-deficit/ hyperactivity disorder and urinary metabolites of organophosphate pesticides." *Pediatrics* 2010. 125(6): e1270–e1277.

This study examines the association between urinary concentrations of organophosphate metabolites and ADHD in children eight to 15 years of age. Researchers analyzed cross-sectional data from the National Health and Nutrition Examination Survey for 1139 children representative of the U.S. population. Urinary DMAP metabolite levels (which are an indicator of exposure to OP pesticides), an ADHD assessment, and household surveys were used in the analysis. The data support the hypothesis that organophosphate exposure, at levels common among U.S. children, may contribute to ADHD prevalence.

Eskenazi B., K. Huen, A. Marks, K.G.Harley, A. Bradman, D.B. Barr, et al. "PON1 and Neurodevelopment in Children from the CHAMACOS Study Exposed to Organophosphate Pesticides in Utero." *Environ Health Perspect*. Aug 2010 118: 1775-1781. See http://dx.doi.org/10.1289/ehp.1002234.

The enzyme paraoxonase 1 (PON1) detoxifies metabolites of some organophosphate (OP) pesticides, andPON1 genetic polymorphisms influence enzyme activity and quantity. The study authors investigated whether PON1 genotypes and enzyme activity levels in mothers and their children were linked to neurodevelopmental changes, and whether PON1 levels and genotypes had an effect on the association of *in utero* exposure to OP pesticides (as assessed by maternal urinary concentrations of dialkyl phosphate metabolites, a marker of OP pesticide exposure) and neurodevelopment and behavior. The researchers found that of the 353 two-year-olds assessed, children with a certain variation of PON1 (the PON1$_{-108T}$ allele) scored more poorly on the Mental Development Index and somewhat lower on the Psychomotor Development Index. The authors concluded that while the variations of PON1 were associated with outcomes in child neurobehavioral development, additional research is needed to confirm whether it modifies the relation with *in utero* exposure to OP pesticides.

Pessah I.N., P.J. Lein. "Evidence for environmental susceptibility in autism" in: *Autism*, (Zimmerman AW, ed). Totowa, NJ: Humana Press 2008 409–428.

The authors aim to illustrate how research into the pathophysiology and genetics of autism may inform the identification of environmental susceptibility factors that promote adverse outcomes in brain development. They highlight three examples of gene-environment interactions that are likely to contribute to autism risk, including: (1) pesticides that interfere with the neurotransmitter acetylcholine; (2) pesticides that interfere with γ-aminobutyric acid (GABA) neurotransmission; and (3) persistent organic pollutants that directly

A Study by Any Other Name…

Epidemiological study: A study of distribution or patterns in health trends or characteristics and their causes or influences in specific populations. Includes both case-control and all types of cohort studies.

Case-control study: Compares a "case" group (e.g., U.S. children ages 0–14 with cancer) with a group serving as a control (e.g., cancer-free U.S. children ages 0–14).

Cohort study: Profiles a specific population where shared exposure may be assumed, such as occupational exposure to pesticides among farmworkers.

Prospective cohort study: Follows a group that is slightly different in some respects. (i.e., studying a cohort of pesticide applicators who use varying protective methods while working with pesticides.)

Longitudinal cohort study: Tracks a specific group over time. For example, a UC Berkeley study on the central California coast has followed a specific group of children from conception through adolescence.

Meta-analysis: Pulls together several studies on the same topic and does further statistical analysis on the basic findings.

Review: Examines the "state of the science" and often provides evaluation of conflicting pieces of data. Review authors give their view on what is currently happening in the field.

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alter calcium ion (Ca^{2+}) signaling pathways and Ca^{2+}-dependent effectors. If both genetic factors and environmental ones converge to interrupt the same neurotransmitter or signaling systems at critical times during development, adverse effects can be amplified.

Rauh V.A., F.P. Perera, M.K. Horton, R.M. Whyatt, R. Bansal, X. Hao X, et al. "Brain anomalies in children exposed prenatally to a common organophosphate pesticide." *Proc Natl Acad Sci* 2012 109(20):7871-6.

This study investigated associations between prenatal exposure to chlorpyrifos and brain morphology (examining brain structure). With a sample of 40 children—who experienced low prenatal exposure to tobacco smoke and polycyclic aromatic hydrocarbons—20 subjects with high chlorpyrifos exposure were compared to 20 low-exposure subjects. The data revealed a significant association between prenatal exposure to chlorpyrifos, at standard use levels, and structural changes in the developing human brain. High exposure was associated with the enlargement of several areas of the brain and in preliminary analyses, the reversal of sex differences or a lack of expected sex differences.

Shafer, T.J., D.A. Meyer and K.M. Crofton. "Developmental Neurotoxicity of Pyrethroid Insecticides: Critical Review and Future Research Needs." *Environmental Health Perspectives* 113, no. 2 Oct 2004: 123–136 .

A review of pyrethroid insecticides and the data related to potential developmental neurotoxic effects of pyrethroids, with recommendations for improving study design and statistical analyses. The review discusses the various effects on voltage-sensitive sodium channels, which are a primary target of pyrethroids.

Childhood cancers

Carozza S.E., B. Li, K. Elgethun and R. Whitworth."Risk of childhood cancers associated with residence in agriculturally intense areas in the United States." *Environ Health Persp* 2008 116(4): 559–565.

Researchers from the U.S. evaluated whether children under the age of 15 who live in a county associated with greater agriculture production—and hence, exposure to pesticide drift—experienced different risk rates for developing cancer. Using incidence data for U.S. children provided by the North American Association of Central Cancer Registries, researchers were able to compare county-level, sex- and age-specific rates of childhood cancer with agricultural census data containing county acreage, percent cropland, and percent acres for specific crops. The data revealed statistically significant increase in risk for many types of childhood cancers for residents living in those counties with a moderate to high level of agricultural activity. Risk for different cancers varied by type of crop; for example, there was increased risk of non-Hodgkin lymphoma and thyroid cancer associated with residence at diagnosis in counties that produced corn or oats.

Infante-Rivard C, S. Weichenthal. Pesticides and childhood cancer: an update of Zahm and Ward's 1998 review. *J Toxicol Environ Health B Crit Rev* 2007 10(1): 81–99.

Infante-Rivard and Weichenthal reviewed the epidemiological and ecological studies published since the 1998 Zahm and Ward review. The authors found that15 case-control studies, four cohort studies, and two ecological studies have been published since this review, and 15 of these 21 studies reported a statistically significant increase in risk of childhood cancer among children whose parents were experienced occupational pesticide exposure. These studies found that the risk of all childhood cancers increased with the frequency of maternal exposure to herbicides and plant insecticides. Furthermore, maternal and paternal exposure to insecticides and herbicides up to five years before having a child increased risk of all childhood brain tumors, astroglial tumors, non-Hodgkin's lymphoma, primitive neuroectodermal tumors, and other glial tumors. Parental occupation in agriculture is also associated with an increased risk of Ewing's sarcoma. The authors conclude that evidence supports an association between at least some pesticide exposure and childhood cancer.

Kristensen, P., A. Andersen, L.M. Irgens, A.S. Bye and L. Sundheim. "Cancer in Offspring of Parents Engaged in Agricultural Activities in Norway: Incidence and Risk Factors in the Farm Environment." *International Journal of Cancer. Journal International Du Cancer.* Jan 1996 65 (1): 39–50.

A cohort study in Norway of 323,359 children born between 1952–1991 reported that children 0-14 years had a nearly doubled risk for brain tumors and a more than tripled risk for neuroepithelial tumors except for astrocytomas associated with pesticide purchase. These associations were stronger when sub-groups, such as growing up on the farm, were considered. Offspring born April–June showed a clustering of neuroepithelial brain tumors, suggesting that paternal exposure during periods of increased pesticide application, from 0–3 months before conception, may have been a factor.

Meinert, R., J. Schuz, U. Kaletsch and J. Michaelis. "Leukemia and Non-Hodgkins Lymphona in Childhood and Exposure to Pesticides: Results of a Register-based Case-Control Study in Germany." *Am Journal of Epidemiology* 2000. 151 (7): 639-646.

A case-control study conducted in Germany from 1993-1997 found parental occupational exposure to be related to childhood cancer regardless of period of exposure and type of cancer, which the authors point out might be due to different recall of past exposures between parents of cases and parents of controls. Residential insecticide use was associated with childhood lymphoma, both professional exterminator and parental usage were significantly associated with increased risk.

Nielsen S.S., R. McKean-Cowdin, F.M. Farin, E.A. Holly, S. Preston-Martin and B.A. Mueller. "Childhood brain tumors, residential insecticide exposure, and pesticide metabolism genes." *Environ Health Persp* 2009 118(1): 144-149.

Researchers in California and Washington found evidence of increased risk of childhood brain tumors (CBT) associated with certain genetic polymorphisms when kids were exposed to insecticides. Strong interactions between genotype and insecticide exposure during childhood was observed. Among exposed children, CBT risk increased per $PON1_{-108T}$ allele, whereas among children never exposed, CBT was not increased. Nielsen et al. concluded childhood exposure to organophosphorus pesticides coupled with a reduced ability to detoxify these pesticides, may be associated with CBT.

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van Wijngaarden E, P.A. Stewart, A.F. Olshan, D.A. Savitz and G.R. Bunin. "Parental occupational exposure to pesticides and childhood brain cancer." *Am J Epidemiol* 2003. 157(11): 989–997.

Researchers from the U.S. evaluated parental exposure to pesticides at home or on the job in relation to the occurrence of brain cancer in children. The sample consisted of children diagnosed with cancer and matching controls from four U.S. states. Interviews were performed with the biological mothers of the subjects to assess the residential and occupational exposure to pesticides in the two years before the child was born. The data revealed a significant risk of astrocytoma associated with residential use and exposure to herbicides. Combining parental exposures to herbicides form both residential and occupational sources, the elevated risk remained significant.

Birth defects

Brender, J.D., M. Felkner, L. Suarez, M.A. Canfield and J.P. Henry. "Maternal Pesticide Exposure and Neural Tube Defects in Mexican Americans." *Annals of Epidemiology*. 2010 20(1): 16–22.

Researchers investigated the relationship between maternal pesticide exposures and neural tube defects (NTDs) in offspring comparing to groups of Mexican American women (184 in case group, 225 for comparison). After adjusting for differences in maternal education levels, smoking, and folate intake during pregnancy, women who reported using pesticides in their homes or yards were twice as likely to have children with NTDs than women not reporting exposures (95% confidence interval [CI], 1.2–3.1) Case-women were also more likely to live within ¼ mile of agricultural fields. As possible sources of pesticide exposure increased, risk of NTDs also increased. Associations were stronger for risk of anencephaly than for spina bifida.

Garry V.F., M.E. Harkins, L.L. Erickson, L.K. Long-Simpson, S.E. Holland and B.L. Burroughs. "Birth defects, season of conception, and sex of children born to pesticide applicators living in the Red River Valley of Minnesota, USA." *Environ Health Persp* 2002. 110(3): 441–449.

A cross-sectional study performed in the Red River Valley of Minnesota examined the reproductive health outcomes in 695 farm families (analyzed data from 1,532 children) from parent-reported birth defects. Researchers determined conceptions in the spring time led to significantly more children born with birth defects, compared to children conceived in any other season. Their data suggests environmental agents present in the spring, like herbicides, have an adverse effect on the birth defect rate. Furthermore, the data revealed an association between fungicide exposure and the determination of child sex—affecting the survival rate of the male fetus (female to male birth ration is 1.25 to 1).

Gaspari L., F. Paris, C. Jandel, N. Kalfa, M. Orsini, J.P. Daures and C. Sultan. "Prenatal environmental risk factors for genital malformations in a population of 1442 french male newborns: a nested case-control study." *Hum Reprod* 2011. 26(11): 3155–3162.

Researchers from France analyzed a physician's examinations and parental interviews for 1442 full-term newborn males in southern France to identify risk factors for male external genital malformations, with a focus on parental occupational exposure to endocrine disrupting chemicals, such as organochlorine pesticides. Infants were examined for cryptochidism, hypospadias, and micropenis, while a questionnaire asked parents about the pregnancy, personal characteristics, lifestyle, and occupational exposure to EDCs. In total, 39 cases of genital malformation were reported (2.70%). A significant relationship was observed between newborn cryptochidism, hypospadias or micropenis and parental occupational exposure to pesticides with the odds of genital malformation increasing 4.41-fold. These data supports the hypothesis that prenatal contamination by pesticides may be a potential risk factor for newborn male external genital malformation.

Rocheleau, C.M, P.A. Romitti and L.K. Dennis. "Pesticides and Hypospadias: a Meta-analysis." *Journal of Pediatric Urology*. Feb 2009 5(1): 17–24.

A meta-analysis of studies done in 7 different countries (Canada, Denmark, Italy, Netherlands, Norway, Spain, US) indicated a 36% increased risk of hypospadia with maternal occupational exposure and a 19% increased risk of hypospadias with paternal occupational exposure.

Winchester PD, Huskins J, Ying J. 2009. Agrichemicals in surface water and birth defects in the United States. *Acta Paediatr* 98(4): 664–669.

Researchers from Indiana and Ohio compared water data from the USGS National Water Quality Assessment (NAWQA)—measuring the levels of nitrates, atrazine, and other pesticides in surface water—and Centers for Disease Control data detailing monthly pregnancy and birth outcome outcomes. The data reveal that between 1996 and 2002 women in the US were significantly more likely to give birth to a child with birth defects if conception had occurred in the months of April through July. NAWQA surface water samples indicate that concentrations of atrazine, nitrates, and other pesticides were also higher in the months of April through July. This correlation was statistically significant, demonstrating elevated concentrations of agrichemicals in surface water coincided with a higher risk of birth defects among live births for children conceived between April and July.

Early puberty

Aksglaede L., K. Sorensen, J.H. Petersen, N.E. Skakkebaek and A. Juul. "Recent decline in age at breast development: the Copenhagen puberty study." *Pediatrics* 2009. 123(5): e932-939.

Researchers from Denmark collected data from 2095 females aged 5.6 to 20 years in two Copenhagen cohorts (1991–1993 and 2006–2008) to examine differences in breast development. Using the most accurate method of palpation, Aksglaede et al. found the onset of puberty—defined as the mean estimated age at the attainment of glandular breast tissue—occurred significantly earlier in the 2006 cohort. The ages at which menarche and pubic hair development occurred also slightly decreased in the 2006 cohort. As a result of these timing changes in early and later markers of puberty, the length of puberty appears to have increased. The authors interpreted these observations as indicative of gonadotropin-independent estrogenic actions at the level of breast development, rather than an earlier activation of the pituitary-gonadal axis. These changes in timing could not be explained by alterations in reproductive hormones and BMI, suggesting other factors involved need to be explored.

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Gladen B., N. Ragan and W. Rogan. "Pubertal growth and development and prenatal and lactational exposure to polychlorinated biphenyls and Dichlorodiphenyl Dichloroethene." ***Pediatrics*** **2000. 136(4): 490-496.**

Researchers from the National Institute of Environmental Health Sciences explored the relationship between prenatal and early-life exposure to PCBs and DDE on children. This is one of a very few studies examining environmental contaminants and male puberty onset. Using 594 children from the North Carolina Infant Feeding Study cohort, they found no effect on the ages at which puberty began. However, the height and weight (adjusted for height) of boys at puberty increased with transplacental exposure to DDE.

Massart F., P. Seppia, D. Pardi, S. Lucchesi, C. Meossi, L. Gagliardi et al. "High incidence of central precocious puberty in a bounded geographic area of northwest Tuscany: an estrogen disrupter epidemic?" ***Gynecol Endocrinol*** **2005. 20(2): 92–98.**

Researchers in Italy preformed an analysis of central precocious puberty (CPP) distribution in northwest Tuscany (NWT). The overall incidence rate of sexual precocity is estimated at 10–20 per 100, a rate similar to that found in four of the cities in the NWT sample; however 47 percent of the CPP cases found in NWT were in the Viareggio area, a rate of 161 per 100,000. This area hosts a high density of navy yards and greenhouses—consequently it is at higher risk of chemical estrogen pollution. As this population represented only 13.73 percent of the total population of NWT, living in this area significantly increased the risk of CPP. The definite geographic distribution of CPP in this suggests that environmental involvement/pollution may be a major determinant of CPP development.

Nebesio T and O. Hirsh Pescovitz. " Historical perspectives." ***Endocrinologist*** **2005. 15(1):44-48.**

Nebesio and Pescovitz reviewed reports alleging endocrine disruptors blamed for altering the age of normal puberty, including an examination of studies implicating pesticides and accidental environmental exposures. Studies reviewed include two seminal studies on early puberty in girls: Vasiliu et al.'s (2004) examination of the Michigan anglers cohort daughters and Krzstevska-Konstantinova et al.'s (2001) examination of precocious puberty in native and non-native Belgian girls. Nebesio and Hirsch Pescovitz (2005) also review Boneh et al. (1989), who examined cases of girls with precocious sexual development from Jerusalem over a 10-year time period and found strong evidence for a seasonal increase in incidences of early sex development observed (from April–June). Seasonal pesticide usage was a potential cause, but the reasons for this were unknown.

Steingraber S. 2007. ***The falling age of puberty in U.S. girls: what we know, what we need to know.*** **The Breast Cancer Fund.**

In this report Steingraber suggests that pubertal onset and menarche are two sexual maturation processes that appear to be becoming uncoupled, therefore increasing the length of puberty in girls. The author cites environmental contaminants as the cause in light of recent evidence suggesting even minimal exposure to an endocrine disruptor on sex hormones can have a profound consequence in childhood.

Obesity & diabetes

Baillie-Hamilton, P.F. "Chemical toxins: a hypothesis to explain the global obesity epidemic." ***J Altern Complement Med*** **2002 8(2): 185–192.**

Hamilton puts forth a new hypothesis to explain the global obesity epidemic: chemical toxins. Overeating and inactivity do not fully explain the current trend in obesity. Baillie-Hamilton calls for an examination of environmental causes rather than genetic factors. The sympathetic nervous system is perhaps the key weight-controlling system, and is targeted by many of the commonest synthetic chemicals. Numerous widely used synthetic chemicals induce weight gain, including pesticides (specifically organochlorines and organophosphates). They do so by disrupting major weight controlling hormones, altering levels and sensitivity to neurotransmitters, interfering with metabolic processes, and causing widespread damage to body tissues. These interferences change appetite, food efficiency, and the metabolism of fats, proteins, and carbohydrates.

Janesick, A. and B. Blumberg. "Endocrine Disrupting Chemicals and the Developmental Programming of Adipogenesis and Obesity." ***Birth Defects Research Part C: Embryo Today*** **Reviews 2011. 93, no. 1: 34–50.**

This review article explores possible explanations for the variation in individual propensity to gain weight and accrue body mass, even at identical levels of caloric input. The authors review evidence from clinical, epidemiological, and biological studies showing that obesity is largely programmed early in life, including prenatally. They examine the environmental obesogen hypothesis, which holds that "prenatal or early life exposure to certain endocrine disrupting chemicals can predispose exposed individuals to increased fat mass and obesity. Obesogen exposure can alter the epigenome of multipotent stromal stem cells, biasing them toward the adipocyte lineage at the expense of bone." Individuals exposed to obesogens early in life or prenatally might thus experience changes in their stem cell compartment, which in turn influences adipogenic fate

Lee D.H., I.K. Lee, K. Song, M. Steffes, W. Toscano, B.A. Baker and D.R. Jacobs."A strong dose-response relation between serum concentrations of persistent organic pollutants and diabetes: results from the National Health and Examination Survey 1999-2002." ***Diabetes Care*** **2006 29(7): 1638–1644.**

Researchers performed a cross-sectional examination of the association between serum concentrations of six POPs (selected because they were detectable in greater than 80 percent of participants) and diabetes prevalence. After adjustments were made for confounding variables (age, sex, race and ethnicity, poverty income ratio, BMI and waist circumference) diabetes prevalence was strongly positively associated with lipid adjustment serum concentrations of all six POPs tested for in the sample of 2,016 adult participants from the National Health and Nutrition Examination Survey 1999–2002. Furthermore, the association between POPs and diabetes was much stronger among obese subjects compared to lean subjects.

Lee, D.H., M.W. Steffes, A. Sjödin, R.S. Jones, L.L. Needham, D.R. Jacobs. "Low dose organochlorine pesticides and polychlorinated biphenyls predict obesity,

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dyslipidemia, and insulin resistance among people free of diabetes." *PLoS One* 2011 6(1): e15977.

In a follow up study to their 2010 study of low-dose persistent organic pollutant (POP) exposure and prediction of type 2 diabetes, Lee et al. conducted a nested case-control study to explore the relationship between serum concentrations of POPs and adiposity, dyslipidemia, and insulin resistance among people confirmed to be diabetes free (assessing study subjects on 5 occasions over 20 years). Researchers concluded that simultaneous exposure to various OC pesticides and PCBs in the general population may contribute to the development of obesity, dyslipidemia, and insulin resistance—common precursors of type 2 diabetes and cardiovascular diseases—among those without diabetes. POPs exposure may also contribute to excess adiposity and other dysmetabolic conditions. Ten POPs were found to predict future higher triglycerides and 14 POPs predicted lower HDL-cholesterol. Among organochorine pesticides, p,p'-DDE most consistently predicted higher BMI, triglycerides and HOMA-IR, as well as a lower HDL-cholesterol at year 20.

Newbold R.R., E. Padilla-Banks, R.J. Snyder, T.M. Phillips and W.M. Jefferson. "Developmental exposure to endocrine disruptors and the obesity epidemic." Reprod Toxicol 2007. 23(3): 290–296.

Research from the US has shown an association between exposure to environmental endocrine disrupting chemicals with the development of obesity. Researchers utilize an animal model of developmental exposure to diethylstilbestrol (DES)—a potent perinatal endocrine disruptor with estrogenic activity—to study the mechanisms involved in programming an organism for obesity. Their data supports the idea that brief exposure early in life to environmental endocrine disrupting chemicals, especially those with estrogenic activity, like DES. These chemicals may contribute to overweight and obesity as well as other obesity-associated diseases (type 2 diabetes and cardiovascular disease). This research complicates the current understanding of obesity and necessitates a consideration of more complex factors, including environmental chemicals.

Asthma

Hernández A.F., T. Parrón and R. Alarcón. "Pesticides and asthma." *Curr Opin Allergy Clin Immunol* 2011 11(2): 90–96.

Hernández et al. performed a review of clinical and epidemiological studies that link exposure to pesticides, asthma attacks, and an increased risk of developing asthma. These authors concluded that while many pesticides are sensitizers or irritants, their potential to sensitize is limited. However, more importantly, pesticides may increase the risk of developing asthma, exacerbate a previous asthmatic condition or even trigger asthma attacks by increasing bronchial hyper-responsiveness.

Salam MT, Y.F. Li, B. Langholz, F.D. Gilliland. "Early-life environmental risk factors for asthma: findings from the Children's Health Study." *Environ Health Perspect* 2003 112(6): 760–765.

Researchers from the University of Southern California selected 4,244 subjects from the Children's Health Study conducted in 12 southern California communities to measure the relationship between childhood environmental exposures and asthma risk. Matching those subjects diagnosed with asthma before age five with asthma-free counterparts that acted as controls (matched for age, sex, community of residence, and in utero exposure to maternal smoking), the authors concluded that environmental exposures during the first year of life are associated with an increase in the risk for early-onset persistent asthma, a subtype of asthma associated with long-term morbidity. Compared to never-exposed children, children exposed to herbicides within the first year of life had a 4.6-fold increased risk of asthma and children exposed to pesticides had a 2.4-fold increase in risk—considered together children exposed to any pesticide or herbicide in the first year of life experience a 2.53-fold higher risk of asthma compared to children who were never exposed to either of those.

Salameh P.R., I. Baldim, P. Brochard, C. Raherison, B.A. Saleh and R. Salamon. "Respiratory symptoms in children and exposure to pesticides." *Eur Respir J* 2003 22(3): 507–512.

Public health researchers from Lebanese University in Lebanon and Victor Segalen Bordeaux II University in France conducted a cross-sectional study to evaluate if exposure to pesticides resulted in chronic effects on the respiratory health of Lebanese children. From 19 public schools, 3,291 randomly selected school children—aged five to 16 years—revealed exposure (residential, paraoccupational, and domestic) to pesticides was significantly associated with respiratory disease (1.82-fold higher) and chronic respiratory symptoms such as chronic phlegm, chronic wheezing, and wheezing at any point (the only exception was chronic cough). Twelve percent of the sample reported a chronic respiratory disease and of those, 84 reported a medically confirmed asthma diagnosis (2.6 percent of the sample).

Sunyer J, M. Torrent, R. Garcia-Esteban, N. Ribas-Fitó, D. Carrizo, I. Romieu et al. "Early exposure to Dichlorodiphenyldichloroethylene, breastfeeding and asthma at age six." *Clin Exp Allergy* 2006 36(10): 1236–1241.

Researchers from Spain and the United Kingdom conducted a longitudinal study from a sample of 468 Minorcan children (Balearic Island in the northwest Mediterranean sea with no local pollution sources) to examine the association between prenatal exposure to DDE and other organochlorine compounds and asthma. Asthma was defined as the presence of a wheeze, persistent wheezing, or parental report of doctor-diagnosed asthma at age four. All children were born with quantifiable levels of DDE and PCB compounds. Wheezing at age four was reported for 11.6 percent of all children. Wheezing at four years of age increased with DDE concentration, particularly at the highest quartile, which was also found for persistent wheezing. This association was maintained even after adjusting for potential confounding variables. These results corroborated the association established between DDE and asthma in German school children conducted by Karmaus et al. in 2001.

I-Fra5

Appendix B: Top Pesticides Used in Agriculture & at Home

Key
? – Insufficient data
ND – No data available
I – Insecticide
H – Herbicide
F – Fungicide
PGR – Plant growth regulator
FUM – Fumigant

Table B-1: Most Commonly Used Pesticide Active Ingredients - Agriculture Listed by volume of use[1]

Pesticide & use level range (millions of lbs active ingredient)	PAN HHP[2]	Type	High[3] acute toxicity	Carcin-ogen	Acute neuro-toxicant (ChE inhibitor)	Devel. or reprod. toxicant	Endocrine disruptor	Primary crops	Food residues[4]
Glyphosate (180-185)		H				?	?	Hay/pasture, soybeans, corn	ND
Atrazine (73-78)	Y	H		Y		?	suspected	Corn, sugarcane	Spinach, wheat, onions, lettuce, water
Metam-sodium (50-55)	Y	FUM	Y	Y		Y	suspected	Potatoes, carrots, tomatoes, onions, peanuts	ND
Metolachlor, (S) (30-35)	Y	H		possible		?	suspected	Tomatoes, beans, corn, cotton	Oats, celery, water, corn
Acetochlor (28-33)	Y	H		Y		?	suspected	Corn, popcorn	Water
Dichlorpropene (27-32)		FUM	Y	Y		?	?	Strawberries, sweet potatoes, tree nuts	
2,4-D (25-29)	Y	H		possible		?	suspected	Grasses, wheat, citrus fruits, tree nuts	Potatoes, water
Methyl bromide (11-15)	Y	FUM	Y			Y	suspected	Tomatoes, strawberries, almonds, peppers, watermelon, cucumbers	ND
Chloropicrin (9-11)	Y	FUM	Y	?		?	?	Tobacco, tomatoes, strawberries, bell peppers	ND
Pendimethalin (7-9)	Y	H		possible		?	suspected	Soybeans, corn, cotton, peanuts	Carrots, collard greens, kale
Ethephon (7-9)		PGR			Y	?	?	Cotton, walnuts, grapes, tomatoes	ND
Chlorothalonil (7-9)	Y	F	Y	Y		?	?	Tomatoes, watermelons, onions	Cranberries, celery, green beans
Metam Potassium (7-9)		FUM	Y	Y		Y	?	Lettuce, potatoes	ND
Chlorpyrifos (7-9)	Y	I			Y	?	suspected	Tree nuts, apples, alfalfa, broccoli, citrus, grapes, sweet corn	Apples, bell peppers, cranberries, kale, grapes, peaches
Copper Hydroxide (6-8)		F				?	?	Tree nuts, grapes, peaches	ND
Simazine (5-7)	Y	H				Y	suspected	Corn, citrus, grapes, tree nuts	Blueberries, kale, water, oranges
Trifluralin (5-7)	Y	H		possible		?	suspected	Soybeans, cotton, green beans, broccoli, tomatoes	Carrots, spinach, wheat, soybeans, broccoli
Propanil (4-6)	Y	H		possible		?	suspected	Rice, oats, barley, wheat	Wheat
Mancozeb (4-6)	Y	F		Y		Y	suspected	Apples, tomatoes, onions, watermelon	ND
Acephate (2-4)	Y	I		possible	Y	?	suspected	Cotton, tobacco, cranberries, mint	Green beans, bell peppers
Diuron[5] (2-4)	Y	H		Y		Y	suspected	Oranges	Asparagus, oranges, water, potatoes
MCPA (2-4)	Y	H	Y	possible		?	?	Flax, barley, wheat, rice	water
Paraquat (2-4)	Y	H	Y			?	suspected	Corn, soybeans, cotton, apples	ND
Dimethenamid (2-4)	Y	H		possible		?	?	Corn, soybeans, sugarbeets	Soybeans, water

Table B-2: Most Commonly Used Pesticide Active Ingredients – Home & Garden

Listed by volume of use

Pesticide & use level range (millions of lbs active ingredient)	PAN HHP	Type	High acute toxicity	Carcinogen	Acute neurotoxicant (ChE inhibitor)	Devel. or reprod. toxicant	Endocrine disruptor
2,4-D (8-11)	Y	H		possible		?	suspected
Glyphosate (5-8)		H				?	?
Carbaryl (4-6)	Y	I		Y	Y	Y	suspected
Mecoprop-P (MCPP) (4-6)	Y	H		possible		?	?
Pendimethalin (3-5)	Y	H		possible		?	suspected
Pyrethroids[6] (2-4)	Y	I	Y	Y		Y	suspected
Malathion (2-4)	Y	I	Y	possible	Y	Y	suspected
Dicamba (1-3)		H				Y	?
Malathion (2-4)	Y	I	Y	possible	Y	Y	suspected
Trifluralin (1-3)	Y	H		possible		?	suspected
Pelargonic Acid (< 1)		H/F		?		?	?

Notes

1 See Table 3.6 and 3.7 in *Pesticide Industry Sales & Usage, 2006 and 2007 Market Estimates*, U.S. EPA, Washington, DC Feb 2011. See www.epa.gov/opp00001/pestsales/07pestsales/market_estimates2007.pdf. Aldicarb was removed from the list as registration was withdrawn in 2010.

2 PAN International has compiled and published a list of Highly Hazardous Pesticides (HHPs) that are harmful to human health and the environment, and targeted for global reduction and elimination. See www.panna.org/issues/publication/pan-international-list-highly-hazardous-pesticides.

3 PAN's online pesticide database provides an explanation of these categories and additional toxicity, use and regulatory information for these and other pesticides. See www.pesticideinfo.org.

4 Based on USDA's Pesticide Data Program, as listed on www.whatsonmyfood.org.

5 Noted health effects not applicable for products with < 7% diuron, and applied to foliage.

6 Health hazards of specific pyrethroids vary, the effects indicated here represent those with most hazardous potential effects.

I-Fra5

Appendix C

Online Resources & Tools

This compilation highlights a number of key online resources available through government agencies and public interest groups. It is not intended to be comprehensive.

Pesticide use data

California pesticide use reporting: *calpip.cdpr.ca.gov*

EPA Pesticide Industry Sales & Usage: *www.epa.gov/opp00001/pestsales*

USDA National Agricultural Statistics Service: *www.nass.usda.gov*

Pesticide health harms

Agency for Toxic Substances & Disease Registry, ToxFAQs: *www.atsdr.cdc.gov/az/c.html*

Collaborative on Health & the Environment, Toxicant & Disease Database: *www.healthandenvironment.org/tddb*

EPA Pesticides & Human Health Issues: *www.epa.gov/opp00001/health/human.htm*

EPA Recognition & Management of Pesticide Poisonings: *npic.orst.edu/rmpp.htm*

Ontario College of Family Physicians, Systematic Review of Pesticide Human Health Effects: *www.ocfp.on.ca/docs/pesticides-paper/pesticides-paper.pdf*

PAN International Highly Hazardous Pesticides: *www.panna.org/issues/publication/pan-international-list-highly-hazardous-pesticides*

PAN's pesticide database: *www.pesticideinfo.org*

Physicians for Social Responsibility, Pesticides & Human Health: A Resource For Health Care Professionals: *www.psr-la.org/resources/reports-training-materials/#Pesticides*

The Endocrine Disruption Exchange (TEDX): *www.endocrinedisruption.com/pesticides.introduction.php*

Pesticides & children's health

Beyond Pesticides, Learning/Developmental Disorders resource page: *www.beyondpesticides.org/health/learningdevelopmental.htm*

Center for Environmental Research & Children's Health: *cerch.org/research-programs/chamacos*

EPA Pesticides & Children: *www.epa.gov/opp00001/health/children.htm*

National Academy of Sciences: *www.nap.edu/catalog.php?record_id=2126*

PAN's Children's health page: *www.panna.org/children*

Pesticide food residues

FDA Total Diet Study: *www.fda.gov/Food/FoodSafety/FoodContaminantsAdulteration/TotalDietStudy/default.htm*

Whats On My Food? database (also includes health effect data): *www.whatsonmyfood.org*

USDA Pesticide Data Program: *www.ams.usda.gov/AMSv1.0/pdp*

Childhood disease & disorders

American Academy of Pediatrics: *www.aap.org*

CDC Child Health Statistics: *www.cdc.gov/nchs/fastats/children.htm*

Children's environmental health

Children's Environmental Health Network: *www.cehn.org*—A national multidisciplinary organization whose mission is to protect the developing child from environmental health hazards and promote a healthier environment.

Children's Environmental Health Project: *www.cape.ca/children*—A project of the Canadian Association of Physicians for the Environment, CEHP is intended to introduce clinicians (and their patients) to children's environmental health issues. Information on the health effects from environmental exposures is presented in a systems approach.

Healthy Child, Healthy World: *healthychild.org*—Protecting children's health and wellbeing from harmful environmental exposures through education and prevention strategies.

Healthy Kids: *www.healthy-kids.info—Provides resources and programs to help educators, health p*rofessionals, community officials, organizations, policy makers and parents work together to ensure schools are safe for children's healthy development.

Learning & Developmental Disabilities Initiative: *www.healthandenvironment.org/initiatives/learning*—An international partnership fostering collaboration among LDD organizations, researchers, health professionals and environmental health groups to address concerns about the impact environmental pollutants may have on children's neurological health.

Making our Milk Safe (MOMS): *www.safemilk.org*—A national grassroots movement of mothers working to create a healthier, safer environment for children, MOMS engages in education, advocacy and corporate campaigns.

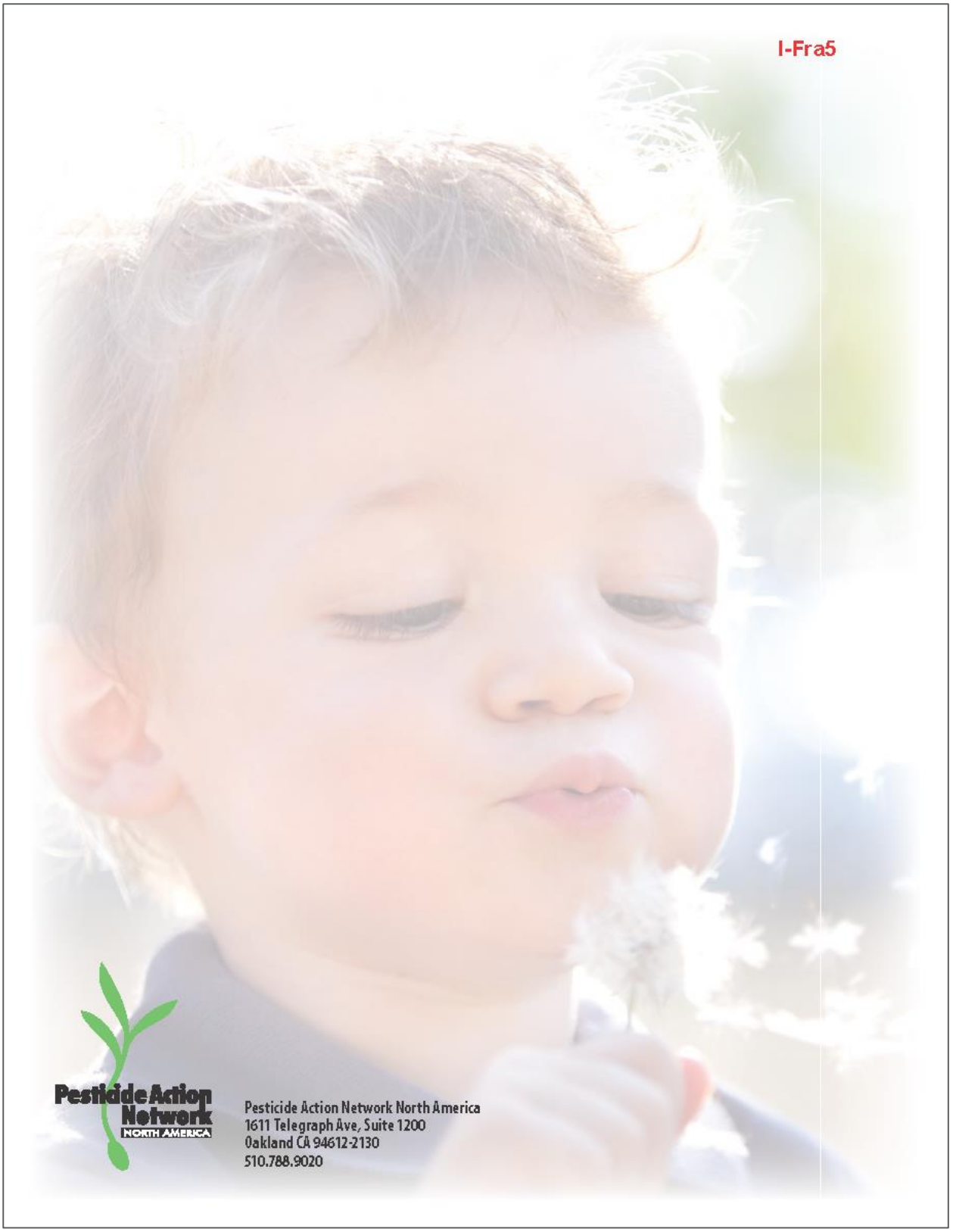
Pediatric Environmental Health Specialty Units: *www.aoec.org/PEHSU.htm*—ATSDR and EPA support this network to provide education for health professionals, public health officials and others about the topic of children's environmental health.

Physicians for Social Responsibility: *www.psr.org/resources/pediatric-toolkit.html*—PSR has developed a pediatric environmental health toolkit that combines easy-to-use reference guides for health providers and user-friendly health education materials on preventing exposures to toxic chemicals and other substances that affect infant and child health. The toolkit is endorsed by the American Academy of Pediatrics.

Safer Chemicals, Healthy Families: *www.saferchemicals.org*—A coalition pressing for reform of national chemicals policy. SCHF represents more than 11 million individuals including parents, health professionals, advocates for people with learning and developmental disabilities, reproductive health advocates, environmentalists and businesses.

The Children's Environmental Health Institute: *cehi.org*—Works to identify, validate and develop solutions to address adverse health effects to children occurring as a consequence of exposure to hazardous environmental substances.

I-Fra5


Pesticide Action Network
NORTH AMERICA
Pesticide Action Network North America
1611 Telegraph Ave, Suite 1200
Oakland CA 94612-2130
510.788.9020

Comment Letter I-Fra5 Fraser, Mary

Response 1

The Pesticide Action Network (PAN) Report covers a long list of pesticides used in agriculture and at home with the thesis that these chemicals are undermining the health of children. The great majority of the products mentioned are not in use or proposed for use by the District, and there is no way to compare the broad generalizations of harm to human health, including endocrine disruption, with the very specific use of pesticides and herbicides for vector control in outdoor environments.

Throughout the brochure, the PAN provides narratives and graphics illustrating numerous diseases in adults and children. The approach by PAN strongly suggests that chemical exposures are the cause of nearly every disease and condition. The comparisons are all based on nonspecific correlations that are not scientifically defensible. The brochure's use of national annual chemical use data and the comparison it provides with national data on diseases and adverse health effects, provides no defensible causality. When the arguments provided in the brochure suggest that national or even regional chemical use can be used to indicate causality to so many diverse diseases, they lose scientific credibility. The comparisons might also relate to hundreds of other genetic and environmental factors. This approach to developing correlation is fatally flawed.

Furthermore, the fatal flaws in the illustrations and correlations provided in this brochure include several correlations that are not supported by the accompanying data. Correlation is not causation. Causation can only be claimed if credible and reproducible data have been developed showing a direct link to documented exposures at the individual level. The claims in the brochure do not show direct correlation and, therefore, cannot be verified.

The materials proposed for use in the District's program are subjected to rigorous initial and ongoing testing and scrutiny for safety by both the US Environmental Protection Agency and the California Department of Pesticide Regulation.

I-Fra6

Marin/Sonoma Mosquito and Vector Control District's
Integrated Vector Management Program Draft PEIR

WRITTEN COMMENT

Name/Affiliation: Mary Fraser Date: 9/17/15

Address: [redacted]

City: Mill Valley Zip Code: 94941 Telephone: [redacted]

Please provide comments and concerns on the content of the Draft PEIR and the potential environmental effects of the Proposed Program.

I have attached copies of 4 emails that I sent to the email address given to me. I did not receive a reply stating that they had been received, so I am sending them again to you with this written comment.

M Fraser

1

peir@msmosquito.com

Please use backside of page for additional comments, if needed. This comment form may be handed in at the public hearing to District staff or mailed to the attention of Philip Smith, to arrive on or prior to **October 2, 2015** at the Marin/Sonoma Mosquito and Vector Control District, 595 Helman Lane, Cotati CA 94931.

Print

I-Fra6

Subject: Comment on Vector Management Program Draft PEIR
From: Mary Mac (mizmerrymac@yahoo.com)
To: peir@msmosquito.com;
Bcc: fegger@pacbell.net; barbogard@gmail.com; kerry.stoebner@gmail.com; w1rothman@gmail.com;
Date: Thursday, September 17, 2015 10:53 AM

Dear Marin Sonoma Mosquito and Vector Control,
I am writing to inform you of my concerns about your Draft PEIR. My concerns are many and I will be sending you multiple emails.
1. You have given the public inadequate time and notice of these hearings and their content. You published a 'legal notice' only on August 28th and expect the public to be able to read and prepare comments no later than Oct. 2, 2015 on a document that is over 500 pages. You made the document available in libraries in CD form. Most libraries have reservation systems in order to use a computer, time is limited to one hour per reservation and to print out any pages is a ten cent fee per page. All of this combined makes for great difficulty in reading and analyzing your Draft PEIR. I am requesting that you extend the official notification period to at least 120 days, that you take out 1/4 page 'display' ads in newspapers and that you send notifications of the Draft PEIR to multiple NGO's and non-profits. I also want you to supply copies of the Draft PEIR to interested individuals at no charge. I have not had adequate time to analyze your entire PEIR.

2. I attended your Public Hearing on Sept. 12, 2015 and watched a power point presentation that was misleading. The presentation stated that you use chemicals approved for organic food production and that you consulted beekeepers. During a very brief review of the Draft PEIR in my one hour computer time allotment at the public library, I found that you propose to use glyphosate. That is a chemical pesticide that is not allowed in organic food production. The World Health Organization thru its research arm, The International Agency for Research on Cancer has declared glyphosate to be carcinogenic to animals, giving glyphosate a 1 rating for animals and a 2A rating for humans.

In reviewing the Draft PEIR I noted that the information on glyphosate is inaccurate in the following ways: a. "Section 4.6.2.3 Human Toxicity. The shikimic acid pathway is specific to plants and some microorganisms; therefore, glyphosate is thought to have very low toxicity to mammals (USEPA 1993)" This is old information. Dr. Stephanie Seneff, MIT and Anthony Samsel have found that the shikimic pathway is present in bacteria in the human gut. Here is their peer reviewed, published paper.
http://people.csail.mit.edu/seneff/Entropy/entropy-15-01416.pdf
Dr. Seneff and Anthony Samsel have published numerous other articles about glyphosate. Here are other articles:
http://people.csail.mit.edu/seneff/ITX_2013_06_04_Seneff.pdf
http://surgicalneurologyint.com/surgicalint_articles/glyphosate-pathways-to-modern-diseases-iii-manganese-neurological-diseases-and-associated-pathologies/
http://people.csail.mit.edu/seneff/Hoy_wildlife_2015.pdf
http://people.csail.mit.edu/seneff/glyphosate/Chen_I_wan_Reference_info_glyphosate_June18_2014.pdf

Glyphosate is rarely used alone. It is almost always used in combination with inerts and adjuvants. A team of independent scientists did studies on the complete formulation of Roundup, which is the most widely used pesticide that has glyphosate as its main ingredient. The testing found that the complete formulations had toxicity levels that were up to 1000x more toxic. Here are two of the studies:

Major Pesticides Are More Toxic to Human Cells Than Their Declared Active Principles
RobinMesnage,[1] Nicolas Defarge,[1] Joël Spiroux de Vendômois,[2] and Gilles-Eric Séralini[1] http://dx.doi.org/10.1155/2014/179691

https://d3n8a8pro7vhmx.cloudfront.net/yesmaam/pages/680/attachments/original/1407922431/2012._Mesnage_et_al._Ethoxylated_adjuvants_of_glyph based_herbicides_are_active_principles_of_human_cell_toxicity.pdf?1407922431
Ethoxylated adjuvants of glyphosate based herbicides are active principles of human cell toxicity.

In Section 4.6.2.3 it is stated " There is currently no published scientific. evidence indicating that glyphosate is carcinogenic or mutagenic". I am attaching a copy of the WHO report that disputes this and that labels glyphosate as carcinogenic to animals and a probable human carcinogen. I don't understand why this report has not been included in the Draft PEIR. The initial release was in March 2015 and the entire monograph was released in July 2015. There have been numerous media reports about the WHO finding!
In Section 4.6.2.1 there is a table of the degradation of glyphosate. Monsanto, the manufacturer of glyphosate has been sued by both the State of New York and the county of France over falsely advertising that their product, Roundup, (which has glyphosate as its active principle) is biodegradable. The county of France won their case, even though it was appealed to the highest court in France and the State of New York settled the case with Monsanto. The degradation of glyphosate is dependent on the chemical nature of the environment it is in. In some cases it can take up to 20 years or more to biodegrade.

All of my referenced attachments should be included in my comments.

Please do not use glyphosate. I want the Directors of the District to approve the No Chemical option that is proposed in your Draft PEIR.
Mary Fraser
110 Seminary Drive, Apt. 2A
Mill Valley, CA 94941
415 686-8072

I-Fra6

Subject: Comments on Draft PEIR

From: Mary Mac (mizmerrymac@yahoo.com)

To: peir@msmosquito.com;

Date: Thursday, September 17, 2015 11:02 AM

I want the Directors of the District to approve the No Chemicals option in the Draft PEIR. Here is a copy of a speech I did on why pesticides should be banned along with its references. Please use this as one of my comments.

WHY PESTICIDES SHOULD BE BANNED.

9/16/15

Thank you Mr. President, Fellow Toastmasters and Welcome Guests,

I want to share this graphic with you. For those of you who can't read it, it says: It's Raining Roundup. With a picture of a little girl playing in the rain. Underneath it says: Monsanto's Roundup found in 75% of air and rain samples. (1) I find this very disturbing. I would think you would find it disturbing too. Pesticides raining on our heads.

I am the mother of three children and have had the unfortunate experience of having a child in the intensive care unit for 35 days. Since I never, ever want to have that experience again, I've educated myself on health hazards. Today I want to share my findings about pesticides with you. I come from a large family of attorneys, so all of my facts in this speech have been verified. I have a copy of this speech available with references to all the facts that I quote.

This graphic was created from data found in official gov't studies. The United States Geographical Survey has done testing in several states and this is what they have consistently found. 75% of the air and rain samples had Roundup in it. (2)

Let me give you a little background on pesticides.

The word Pesticide means death to pests. It is an umbrella term. Under the umbrella, we have herbicides or death to plants, insecticides or death to animals and fungicides or death to fungi. Many people think that a more apt term for pesticide is ecocide. Death to the environment.

Now imagine that this jar is a can of pesticide. Inside this jar, there is the main ingredient or what is technically called the 'active principle'. This is the chemical that the EPA requires manufacturer's to do testing on. The manufacturer's do the testing. The EPA only reviews the tests. Along with the active principle, there are inerts and/or adjuvants added to the formula. Under EPA rules, the inerts and adjuvants do not need to be tested. They do not need to be disclosed to the public as they can be considered to be trade secrets or proprietary business information. So what you have, is a can of chemicals of completely unknown toxicity, untested and undisclosed. (3) Now many of you have gone to your doctor and when he wants to write you a prescription, he always asks about other drugs you are taking. He doesn't want any unforeseen chemical reactions. I guess the EPA didn't get that memo. This is the dirty little secret of pesticides and one of the dirty little secrets about the EPA. Now, after the manufacturer has created this pesticide of unknown toxicity, they are often patented. Once patented, no one can do research on the formula without the patent holders permission. Fat chance.

Let me go back to the graphic. " It's Raining Roundup." The active principle or main ingredient in Roundup is glyphosate. The World Health Organization has just declared that glyphosate causes cancer in animals. (4) They declared it to be a 'probable human carcinogen' only because they could not find enough enough scientific studies on humans and glyphosate. It is unethical to try to induce cancer in humans and the few studies they had just didn't have enough data.

The patent has run out on Roundup and a group of independent scientists did studies on it. What they found was that Roundup was 1000x more toxic than its main ingredient glyphosate. 1000x time more toxic. (5) Roundup is the most widely used pesticide in this country. We use millions of pounds of it per year. (6) It's what genetically modified crops like corn, soy , canola, sugar beets, alfalfa and cotton are designed to withstand heavy doses of. (7) 80% of all processed foods contain GMO ingredients. (8) It's allowed on 160 different food crops in this country. (9) Farmers spray it on many crops right before harvest to eliminate weeds and dry out the crops. Right before harvest. So many of us are now gluten intolerant. Well, Roundup is oftentimes sprayed on wheat right before harvest. You're not gluten intolerant. You're being poisoned. (9) And no one tests for residues of Roundup on our food. That's another dirty little secret about the EPA. (10) We test for other pesticides but not Roundup.

So what are the public health consequences of all this toxicity? According to the American Cancer Society, the official rate of cancer in 2015 is now 1 in 2. That's for men. 1 in 2. For women its 1 in 3. (11) And that is just cancer. Roundup has been linked to 32 other chronic diseases (12) and has been found in breast milk, urine (13) and now it's raining Roundup.

So what can you do? If you have Roundup at home, carefully take it to the hazardous waste facility. Eat only organic food and you will avoid about 80% of pesticides. This is particularly important for children as they eat more per lb. of body weight than adults do and their bodies do not have the same capacity to detox pesticides as adults do. (14)

And exercise your democratic rights. The Marin Co Board of Supervisors has the issue of banning pesticides on its agenda on Oct. 6th. Let them know what you think. The CA EPA has opened comments about adding Roundup to its list of Prop. 65 chemicals and our Mosquito abatement program is proposing to use Roundup. I have notices on all of these actions and I have information on eating organic food .

Let me close with another graphic. This is a quote from Dr. Don Huber, a professor emeritus of Plant Pathology, Purdue University.

"Future generations will judge us- not on how many millions of tons of pesticides we sprayed, but on how willing we were- how perfectly willing we were, to sacrifice our children". (16)

Thank you. You have my permission to share this speech with anyone or to contact me if you wish a copy of this speech in electronic form.

I-Fra6

Mary Fraser

Email: mizmerrymac@yahoo.com

References:

1. https://www.facebook.com/pages/Monsanto-Class-Action/992106394134272?sk=photos_stream
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2. http://www.usgs.gov/newsroom/article.asp?ID=2909#.VfnIlNVViko
http://www.greenmedinfo.com/blog/roundup-weedkiller-found-75-air-and-rain-samples-gov-study-finds
http://www.ncbi.nlm.nih.gov/pubmed/24549493
http://www.ncbi.nlm.nih.gov/pubmed/18453431
http://www.ncbi.nlm.nih.gov/pubmed/21128261

3. **Poison Spring: The Secret History of Pollution and the EPA Hardcover – April 8, 2014**
by E.G. Vallianatos (Author), McKay Jenkins (Author)

1. International Agency for Research on Cancer, **IARC Monographs Volume 112: evaluation of five organophosphate insecticides and herbicides.**

2. Hindawi Publishing Corporation

BioMed Research International
Volume 2014, Article ID 179691, 8 pages
Major Pesticides Are More Toxic to Human Cells Than Their Declared Active Principles
RobinMesnage,1 Nicolas Defarge,1 Joël Spiroux de Vendômois,2 and Gilles-Eric Séralini1 http://dx.doi.org/10.1155/2014/179691

https://d3n8a8pro7vhmx.cloudfront.net/yesmaam/pages/680/attachments/original/1407922431/2012._Mesnage_et_al._Ethoxylated_adjuvants_of_glyph based_herbicides_are_active_principles_of_human_cell_toxicity.pdf?1407922431
Ethoxylated adjuvants of glyphosate based herbicides are active principles of human cell toxicity.

1. **http://www.sciencedirect.com/science/article/pii/S027869151530034X**

Potential toxic effects of glyphosate and its commercial formulations below regulatory limits

7. **https://d3n8a8pro7vhmx.cloudfront.net/ncap/pages/26/attachments/original/1428423381/glyphosate.pdf?1428423381** **JOURNAL OF PESTICIDE REFORM/ WINTER 2004 • VOL. 24, NO. 4 HERBICIDE FACTSHEET**

1. Ibid

2. http://d3n8a8pro7vhmx.cloudfront.net/yesmaam/pages/680/attachments/original/1393210109/Glyphosate_II_Samsel-Seneff_Toxicology_FNL.pdf?1393210109
Glyphosate, pathways to modern diseases II: Celiac sprue and gluten intolerance
Anthony SAMSEL 1 and Stephanie SENEFF 2 1 Independent Scientist and Consultant, Deerfield, NH 03037, USA 2 Computer Science and Artificial Intelligence Laboratory, MIT, Cambridge, MA, USA ITX060413R01 • Received: 24 September 2013 • Revised: 10 November 2013 • Accepted: 12 November 2013

3. http://www.ecfr.gov/cgi-bin/text-idx?SID=195f8b224b4d7d5ab8cfff3bf0f92f68&node=se40.24.180_1364&rgn=div8
Electronic Code of Federal Regulations 180.364 Glyphosate, tolerances for residues.

4. www.consumerreports.org/cro/news/2015/03/glyphosate-in-your-diet/index.htm
Consumer Reports: Is there glyphosate in your diet? No one knows how much of this pesticide is in the produce we eat.

5. **American Cancer Society publication: Cancer Facts & Figures 2015, page 14.**
http://www.cancer.org/acs/groups/content/@editorial/documents/document/acspc-044552.pdf

6. **http://people.csail.mit.edu/seneff/Swanson_et_al_2014.pdf**
Journal of Organic Systems, 9(2), 2014 ORIGINAL PAPER
Genetically engineered crops, glyphosate and the deterioration of health in the United States of America
Nancy L. Swanson1 , Andre Leu2 *, Jon Abrahamson3 and Bradley Wallet4

http://www.examiner.com/article/data-trends-show-correlation-between-increase-organ-disease-and-gmos

7. **Glyphosate Testing Report: Findings in American Mothers' Breast Milk, Urine and Water.**
Conducted by Moms Across America and Sustainable Pulse
April 7, 2014.
Zen Honeycutt, Moms Across America, Henry Rowlands, Sustainable Pulse

8. Pesticide Action Network North America, **"A Generation in Jeopardy, How pesticides are undermining our children's health & intelligence".**
http://www.panna.org/publication/generation-in-jeopardy

Sincerely,

Mary Fraser

110 Seminary Drive, Apt. 2A

Mill Valley, CA 94941

415 686-8072

I-Fra6

Subject: Comment on Draft PEIR

From: Mary Mac (mizmerrymac@yahoo.com)

To: Peir@msmosquito.com;

Date: Thursday, September 17, 2015 11:13 AM

Dear District Board of Directors and Staff,
Please choose the No Chemical option from your draft PEIR. Pesticides drift, so you cannot guarantee anyone that you will not affect them. Pesticides get into our air and our water. I am attaching a speech that I recently wrote about pesticides, drift and their threat to the $45 million dollar agricultural market in Marin.
My name is Mary Fraser and I am a resident of Marin County. I am here today to ask you to ban the use of pesticides on Marin County Open Spaces and Parks. I am asking Parks and Open Space to become organic.

I want to share this graphic with you. For those of you who can't read it, it says: It's Raining Roundup. With a picture of a little girl playing in the rain. Below it, it says Monsanto's Roundup in 75% of Air and Rain Samples. This graphic has been created from a study done by the US Geological Survey. The following quotes are from their study.

"Pesticides can become airborne through volatilization and wind erosion of particles both during and after their application. Volatilization from treated areas is a continuous process and can be a major dissipative route for many pesticides. Airborne pesticides can be carried by wind and deposited in unintended areas by dry (gas and particle) and wet (rain and snow) deposition." This is what is commonly known as drift.

Marin County has organic agriculture that is worth $46 million dollars per yr. $46 million dollars per yr. There are 66 registered organic operations. The drift from the use of pesticides on Open Space and Parks may jeopardize that $46 million dollars or it may drift into more populated areas and contribute to health problems. No one knows where it will go. We just know that pesticides drift.

Coincidentally, I also just happened to sign up for the Marin Organic newsletter. I want to read you the reply I received.

Hi Mary,

I just wanted to send a quick note to thank you for signing up.

When the founders of Marin Organic first met in the mid-1990's they envisioned a county free of herbicides and pesticides and hoped that organic would become the new norm. Well, today we're

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proud to say that the majority of productive farmland in Marin County is certified organic. We're still here carrying on that mission, and part of that is educating folks through our newsletters.

Jeffrey Westman-Executive Director Marin Organic

Please join Marin Organics vision of Marin County as a place free of herbicides and pesticides.

Attached are documents regarding the USGS studies that I referenced above.

Mary Fraser

110 Seminary Drive, Apt 2A

Mill Valley, CA 94941

http://www.usgs.gov/newsroom/article.asp?ID=2909#.VfnIlNVViko

1. http://www.greenmedinfo.com/blog/roundup-weedkiller-found-75-air-and-rain-samples-gov-study-finds
   http://www.ncbi.nlm.nih.gov/pubmed/24549493
   http://www.ncbi.nlm.nih.gov/pubmed/18453431
   http://www.ncbi.nlm.nih.gov/pubmed/21128261

I-Fra6

Subject: Comment on Draft PEIR

From: Mary Mac (mizmerrymac@yahoo.com)

To: Peir@msmosquito.com;

Bcc: fegger@pacbell.net;

Date: Thursday, September 17, 2015 11:27 AM

Dear District Board of Directors and Staff,
I urge you to choose the No Chemical option from the Draft PEIR. Many other places are understanding how detrimental to the environment and human health the use of pesticides are. Attached is a list of many other places that have either banned or restricted pesticides. Here is the text of a speech that I gave about the other places that have banned pesticides and their reasons for doing so.

Board of Supervisors and Ladies and Gentlemen,

My name is Mary Fraser. I am a resident of Marin Co.

I am here today to urge you to ban pesticides in Marin County. Today I want to talk about other places that have banned pesticides and why they chose to do so. Each place is a little different but they all chose public health over the use of pesticides.

As you may know, the Marin Municipal Water District recently chose to exclude the use of pesticides from the 26,000 acres they manage. This is a continuation of a 9 yr. hiatus in the use of pesticides. No one wants pesticides in our water supply.

Richmond CA has banned pesticides. This effort was led by 2 doctors, one of whom is the retired chief of cardiology for Kaiser Permanente. Dr. Jeff Ritterman wrote and published an extensive article outlining the public health reasons for banning pesticides. I had the privilege to hear Dr. Ritterman speak recently. He started his talk by saying that the compelling evidence against pesticide use was the birth defects that are showing up in South America. We are talking about babies born with no skull. Babies born with no arms AND no legs. Babies born with one big cyclops eye. Defects nearly identical to the ones that happened in VietNam after we defoliated the country with Agent Orange. And we did not ban the entire formula of Agent Orange. Only 2, 4 T. We still use 2, 4 D on our agriculture.

So in Argentina, because of the health consequences, 30,000 doctors have called for a ban on pesticides. 30,000 doctors.

In El Salvador, 20,000 men have died in the last 5 years because they started using pesticides in the sugar cane fields. In El Salvador they've banned 32 different pesticides.

Sri Lanka has the same issue. Thousands are dying from kidney disease. One of the reasons that they have such terrible kidney diseases is because they have serpentine soil. We have serpentine soil in Marin. Sri Lanka has banned pesticides.

I-Fra6

France has banned them. The Netherlands has banned non commercial use. German ministers are calling for a ban in the entire European Union. All of these countries operate on the precautionary principle, where chemicals have to be proven safe before they can be used. In America, we have the opposite policy. Chemicals undergo minimal testing by the manufacturer and then the public has to prove that a chemical is unsafe before it can be forced off of the market. This can take decades and have untold consequences.

So I'm asking the Board of Supervisors to be our heroes and ban pesticides on all of the property that the County of Marin owns, leases and manages, including Open Space.

Places where the use of glyphosate and/or pesticides are restricted or banned.

Marin County:

Marin Municipal Water District, Marin County, CA. 22,000 acres of watershed- Pesticides banned. Vote taken 7/7/15 http://www.marinij.com/environment-and-nature/20150708/marin-water-district-herbicides-wont-be-used-on-mount-tam

City of Fairfax, CA- Pesticides banned on commons.

City of Belvedere, CA- Pesticides banned on commons.

City of Sausalito, CA-Pesticides under review

Reed School District, Tiburon, CA- Pesticides not used on school district grounds.

Larkspur-Corte Madera School District, Corte Madera, CA-Pesticides not used on school grounds.

Mill Valley School District, Mill Valley, CA- Pesticides not used on school grounds.

States:

Connecticut: Pesticides banned on municipal playgrounds:

http://www.beyondpesticides.org/dailynewsblog/2015/07/connecticut-bans-toxic-lawn-pesticides-in-municipal-playgrounds-statewide

New York: Pesticides banned on school grounds

Countries:

Country of the Netherlands- Glyphosate banned for non-commercial use.
http://sustainablepulse.com/2014/04/04/dutch-parliament-bans-glyphosate-herbicides-non-commercial-use/#.VZ2Wca5Vikp

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Country of Sri Lanka-Glyphosate banned
http://www.publicintegrity.org/2014/03/13/14418/sri-lanka-bans-monsanto-herbicide-citing-potential-link-deadly-kidney-disease.

County of El Salvador- Glyphosate banned by legislature.

Country of Bermuda- Glyphosate imports suspended.
http://www.todayinbermuda.com/news/health/item/1471-health-minister-importation-of-roundup-weed-spray-suspended

Country of Brazil. Chief prosecutor wants glyphosate banned.
http://www.globalresearch.ca/brazils-public-prosecutor-wants-to-ban-monsantos-chemicals-following-recent-glyphosate-cancer-link/5449440

Country of Germany and the European Union (EU). EU ban proposed by ministers.
http://www.globalresearch.ca/german-ministers-call-for-eu-wide-ban-on-monsantos-deadly-glyphosate-herbicide-roundup/5451831

1. Country of Argentina. 30,000 medical doctors call for ban on glyphosate.
http://www.globalresearch.ca/30000-doctors-in-argentina-demand-that-glyphosate-be-banned/5445542

Country of Columbia. Glyphosate banned for use on illicit crops. http://www.bbc.com/news/world-latin-america-32677411

Country of France. Sale of glyphosate banned.
http://www.naturalnews.com/050248_french_legislation_glyphosate_ban_Monsanto_GMOs.html

States:

Connecticut: Pesticides banned on municipal playgrounds:

http://www.beyondpesticides.org/dailynewsblog/2015/07/connecticut-bans-toxic-lawn-pesticides-in-municipal-playgrounds-statewide

New York: Pesticides banned on school grounds

Cities:

City of Richmond, CA- Moratorium on organophosphate pesticides

Chicago, IL,

Takoma Park, MD

Laguna Hills, CA

I-Fra6

Durham, CT

Paris, France

University of Vermont Law School and Emory University campuses have banned all pesticides

Santa Barbara, CA

Carrboro, NC

Plainville, CT

Santa Fe, NM

The township of Marblehead, Massachusetts instituted one of the earliest ordinances calling for the use of Organic Land Care on township lands and has successfully implemented fully organic techniques for turf management.

Between 1996 and 2005 San Francisco municipal agencies achieved an 85% reduction in gallons of liquid pesticide, a 55% decrease in pounds of solid pesticides, and a 90% decrease in the use of Roundup®, one of the herbicides most widely used by municipalities. San Francisco has been so successful that in 2005 New York City passed a similar local law based largely on San Francisco's ordinance.

Mary Fraser
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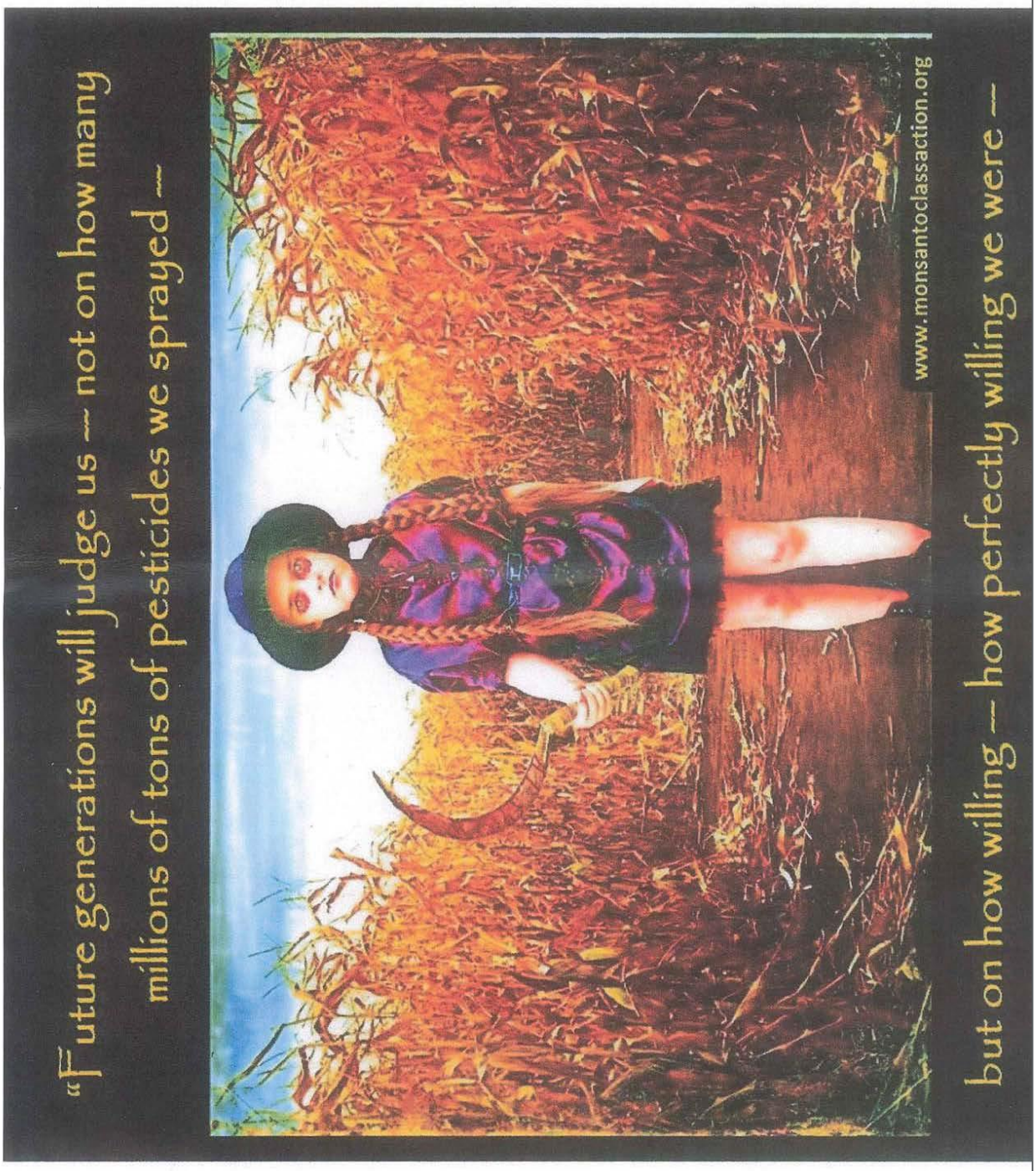
I-Fra6


"Future generations will judge us – not on how many
millions of tons of pesticides we sprayed –
but on how willing – how perfectly willing we were –
www.monsantoclassaction.org

Comment Letter I-Fra6 — Fraser, Mary

Response 1

These emails were received and have been addressed as responses to comments I-Fra1 through I-Fra4.

I-Fra7

Marin/Sonoma Mosquito and Vector Control District's Integrated Vector Management Program Draft PEIR

WRITTEN COMMENT

Name/Affiliation: Mary Fraser Date: 9/17/15

Address: [redacted]

City: Mill Valley Zip Code: 94941 Telephone: [redacted]

Please provide comments and concerns on the content of the Draft PEIR and the potential environmental effects of the Proposed Program.

Attached scientific study on pesticides and erectile dysfunction.

Attached graphic - "It's raining Roundup"

1

Please use backside of page for additional comments, if needed. This comment form may be handed in at the public hearing to District staff or mailed to the attention of Philip Smith, to arrive on or prior to **October 2, 2015** at the Marin/Sonoma Mosquito and Vector Control District, 595 Helman Lane, Cotati CA 94931.

Asian Pacific Journal of Reproduction 2015; ■(■): 1-9

I-Fra7 1

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Contents lists available at ScienceDirect

Asian Pacific Journal of Reproduction

journal homepage: www.apjr.net

Review http://dx.doi.org/10.1016/j.apjr.2015.07.012

Potential pathways of pesticide action on erectile function – A contributory factor in male infertility

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ARTICLE INFO

Article history:
Received 12 Dec 2014
Received in revised form 10 Jun 2015
Accepted 20 Jul 2015
Available online xxx

Keywords:
Pesticides
Erectile function
Infertility

ABSTRACT

One of the important objectives of this manuscript is to focus on the place of erectile dysfunction as an important factor for infertility. The review is about correlating the indiscriminate use of pesticides and to find out and highlight the evidences for mechanism of action of these pesticides for erectile dysfunction and find out the most used and most dangerous pesticide from erectile dysfunction point of view. The review suggests that erectile dysfunction is having a significant place as a causal factor for infertility. Study infers that pesticides are having multiple mechanisms of action through which these cause erectile dysfunction. It also reflects that acetamiprid is having most devastating effect causing erectile dysfunction as it acts through multiple inhibitory pathways. The review successfully highlights the indiscriminate regional use of pesticides.

1. Introduction

Male fertility is reported to be declining day by day. According to recent estimates every year about 60–80 million couples all over world suffer from infertility of which probably between 15 and 20 million are in India alone [1]. Researchers have shown that male factors account for 40%–50% of infertility in human [2,3] and one of the major problems contributing towards male infertility is erectile dysfunction afflicting as much as 10% of the male population [4]. The data are more alarming above the age of 40 as nearly 52% of men are afflicted. There is enumerable number of factors like psychological factors, physiological, pathological, social, environmental, nutritional etc that play a major role in pathogenesis of erectile dysfunction. Today environment is laced with heavy metals, radioactivity, poisonous fumes of organic chemicals, pesticides that may attribute for erectile dysfunction.

Incidentally it has been reported that a number of birth defects and infertility problems are being faced in the pesticide afflicted areas in India and abroad [5]. Reports also depict that pesticides may cause erectile dysfunction [6]. A number of mechanisms have evolved for erectile dysfunction by various pesticide residues in the body. The purpose of this compilation is to put all the mechanisms of action of different pesticides at one platform so as to enable the researchers, physicians and regulatory authorities to design check points for dreaded chemicals being pumped in the environment. It will also give an idea about a pesticide that is having potential multiple toxic effects through different mechanisms.

2. Major causes of male infertility

Before going into details of different mechanism of actions, it is pertinent to enumerate some common factors that affect male fertility. Male infertility is commonly due to deficiencies in the semen and semen quality is used as a surrogate measure of male fecundity [7]. Some of the pre-testicular factors impede adequate support of the testes and include situations of poor hormonal support and poor general health including hypogonadism; drugs such as cimetidine that decrease follicle stimulating hormone (FSH) levels, and nitrofurantoin that decreases sperm motility; adopted life style (marijuana, cigarette smoking); and strenuous activities such as strenuous bicycle riding [8]. Testicular factors affect quality and quantity of semen produced by the testes and include age, genetic defects of the Y-chromosome (Klinefelter syndrome), neoplasm e.g. seminoma, cryptorchidism, varicocele which account for 14% [9], mumps viral infection [10] and may be idiopathic which accounts for 30% of male infertility [11]. USP 26 a peptidase enzyme expressed by USP 26 an X-linked gene in testis has been found to be defective in some cases of birth defects [12]. Besides this, there are some Post-testicular factors that decrease male fertility due to conditions that affect the male genital system after testicular sperm production and include defects of the genital tract as well as problems in

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Peer review under responsibility of Hainan Medical College.

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ejaculation: e.g. impotence, Vas deferens obstruction, lack of Vas deferens, infection e.g. prostitis, ejaculatory duct obstruction and hypospadias [13].

Other important factor are conditions that affect the hypothalamus and pituitary gland will eventually affect the gonadotropin releasing hormone (GnRh) and hence the levels of follicle stimulating hormone, luteinizing hormone and prolactin hormone. These conditions include Kallmann syndrome (isolated gonadotropin deficiency), hyperprolactenemia and hypopituitarism. Hyperprolactinemia may be due to diseases affecting the hypothalamus and pituitary gland or secondary to disease of other organs such as the liver, kidneys and thyroid [14]. Hyperprolactinemia may cause hypogonadism, erectile dysfunction, decreased libido and infertility [15].

The etiological importance of environmental factors in infertility has also been stressed [16]. The implication of toxins such as glues, volatile organic solvents, silicones, physical agents, chemical dusts and pesticides in infertility has already been established [17]. Radiations and excessive heat to the genitalia have damaging effect on the testicles. Hence individuals having direct contact with or exposure to such chemicals have high chances of having primary or secondary infertility as the case may be. Estrogen-like hormone-disrupting chemicals such as phthalates are of particular concern for infertility in men and for effects on offspring of women. Exposure to phthalates can occur via dietary consumption, dermal absorption or inhalation and has been linked with impaired spermatogenesis and increased sperm DNA damage [18,19]. The mechanism for this is probably due to increase in the generation of reactive oxygen species (ROS) within the testis and a concomitant decrease in antioxidant levels, culminating in impaired spermatogenesis as observed in rats [20]. The contribution of tobacco smoking and alcohol intake to infertility has also been demonstrated. Tobacco smoking was observed to damage sperm DNA [21]. Though some of the damage is irreversible, but stopping smoking can prevent further damage [22]. It has been reported that smokers are 60% more likely to be infertile than non-smokers. Smoking reduces the chances of IVF producing a live birth by 34% and increases the risk of an IVF pregnancy miscarriage by 30% [23]. Smokers have decreased levels of antioxidants such as Vitamin E and Vitamin C, placing their spermatozoa at additional risk of oxidative damage.

Sexually transmitted diseases (STD) have also proved to be a leading cause of infertility. They are often asymptomatic but may display few symptoms, with the risk of failing to seek proper treatment in time to prevent decreased fertility [22]. Some of the identified STDs (such as syphilis, trichomoniasis, chancroid, chlamydia, gonorrhea, herpes simplex virus, human papilloma virus, lymphogranuloma venerum) are treatable while many are not and may eventually lead to death. Similarly the urinary tract has a relative anatomical association with the reproductive tract. Escherichia coli and Staphylococcus aureus are reported to be the most prevalent Gram negative and Gram positive organisms implicated in UTI respectively [24].

Obstructive azoospermia may result from previous vasectomy; epididymal, vassal, or ejaculatory duct pathology relating to genitourinary infection; iatrogenic injury during inguinal or scrotal surgery and congenital anomalies [25]. Azoospermia (low sperm counts), abnormal spermatozoa morphology (shape) and low sperm motility are usually asymptomatic conditions to most males but of great etiological importance. It is well recognized that sperm DNA can be damaged oxidatively by oxidative stress [26] and nonoxidatively by mechanisms such as aberrant apoptosis and incomplete sperm protamination [27].

3. Microorganisms and infertility

Microbial infections have been reported to reduce sperm viability. Staphylococcus aureus is the most prevalent Gram positive organism, while Escherichia coli is the most prevalent Gram negative organism isolated in the semen of males with primary infertility [28]. Chronic epididymitis secondary to Chlamydia trachomatis infection had been shown to blockage of the epididymis and thus obstructive azoospermia [29]. However, Ureaplasma urealyticum infections induce leukocytospermia and consequently lead to sperm damage, decrease sperm counts and invariably impaired sperm motility [30]. Herpes simplex virus (HSV) was reported to have been found in the semen of some infertile men and was related to low sperm count and poor motility [31]. Mumps viral infections in adolescent and adult males carry about 30% risk of developing orchitis or epididymitis, which can result in testicular atrophy and sterility [32].

4. Chemotherapy and infertility

Studies have shown that the antral follicle count decreases after the third series of chemotherapy, whereas follicle stimulating hormone (FSH) reaches menopausal levels after the fourth series; inhibin B and anti Mullerian hormone levels have been reported to decrease following chemotherapy [33]. Drugs with high risk of infertility include procarbazine, cyclophosphamide, ifosfamide, busulfan, melphalan, chlorambucil and chlormethine; drugs like doxorubicin, cisplatin and carboplatin have medium risk while therapies with plant derivatives (such as vincristine and vinblastine), antibiotics (such as bleomycin and dactinomycin) and antimetabolites (such as methotrexate, mercaptopurine and 5-fluoruracil) have low risk of gonadotoxicity [19].

5. Psychological/physical/behavioral problems

Several sexual problems exist that can affect male fertility. These problems are most often both psychological and physical in nature. It is difficult to separate the physiological and physical components. Stress can be an important reason for infertility. Ejaculatory incompetence is a rare psychological condition that prevents men from ejaculating during sexual intercourse even though they can ejaculate normally through masturbation. This condition sometimes responds well to behavioral therapy.

Above all one of the main upcoming reasons for male infertility is pesticides. Experimental evidence in the laboratory has linked the chemicals present in pesticides to reduced sperm quality, testicular cancer and reproductive abnormalities. The chemicals work by "blocking" the activity of hormones, known as androgens, which influence the development of the male reproductive system. Several studies have suggested that human semen quality and fecundity is declining [34–46]. A pesticide is "any substance or mixture of substances intended for preventing, destroying or controlling any pest, including vectors of human or animal disease, unwanted species of plants or animals causing harm during or otherwise interfering with the production processing, storage, transport or marketing of food, agricultural commodities, wood and wood products or

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animal feedstuffs, or substances which may be administered to animals for the control of insects, arachnids or other pests in or on their bodies". They fall into three major classes: insecticides, fungicides, and herbicides, Based upon the target organism classification these are also rodenticides, nematicides, molluscicides and acaricides [47]. Another classification categorizes pesticides according their chemical structure. Insecticides include organochlorines, organophosphates, and carbamates. Organophosphate and carbamates are less toxic and largely replaced organochlorines.

Pesticides may differ according to their chemical structure, their mechanism of action and the toxicity they exhibit, but typically each pesticide consists of one (or more) active ingredient, which exerts the pesticidal activity, and an inert ingredient, which is inactive and helps in handling the active ingredient. Several studies have shown that the inert ingredient is not as inactive as it was previously believed to be [47,48]. Over 700 active ingredients are in use worldwide as pesticides, each with distinct chemical and toxicological properties [49].

In addition to the desired effects of crop protection and pest management, pesticides have some recognized adverse impacts on human health and the environment. Humans have a great risk of exposure through several pathways in occupational, agricultural and household use. Inhalation, oral, dermal and ocular is four possible routes for pesticide exposure. Ingestion of food and water is thought to be the main routes of pesticide exposure in the general population, while dermal absorption is suspected to be the main source of occupational exposure [49]. Over 25% of fruits, vegetables, and cereals are known to contain detectable residues of at least two pesticides and more than 300 different pesticides are known to contaminate food products sold in the EU. [50]. In the majority of cases, however, human exposure is unintentional and unintended [51,52]. Pesticides disrupt different mechanisms in the body.

6. Different mechanisms of action of pesticides causing erectile dysfunction

6.1. Pesticides can be the reason of erectile dysfunction

Penile erection is a complex neurovascular phenomenon. It involves the coordination of three hemodynamic events: increased arterial inflow, sinusoidal smooth muscle relaxation and decreased venous outflow. It also implies the interaction of the brain, nerves, neurotransmitters, smooth muscles and striated muscles. An alteration in any of these components may affect the response of the erectile tissue and cause erectile dysfunction [53–57]. The effect of the normal aging process on erectile function is unknown and the cause of age-related dysfunction is likely to be multifactorial in origin [58]. Pesticides act via different mechanism like oxidative stress, lowering testosterone levels, etc. [59–61]. Pesticides are responsible for decreasing testosterone concentration either by inhibiting release of FSH or LH [62]. Pesticides are also responsible for apoptosis of leydig cells and hence decreasing overall concentration testosterone. Pesticides also cause increase secretion of hypothalamic corticotrophin releasing hormone which stimulates release of adrenocorticotropic hormone (ACTH) and so cortisol [63] which inhibits GnRH and so LH and testosterone decreases. So, all the above written pathways are responsible for decreasing testosterone concentration. Alterations in blood vessels, hormonal changes, neurologic dysfunction, medication and associated systemic diseases are the main causes of erectile dysfunction [64].

6.2. Pesticides inhibit acetylcholine esterase

An acetylcholine esterase inhibitor (AChEI) or anticholinesterase is a chemical that inhibits the acetylcholine esterase enzyme from breaking down acetylcholine (Figure 1), thereby increasing both the level and duration of action of the neurotransmitter acetylcholine. Existence of reversible, quasi-irreversible and irreversible inhibitors of ACh like chloropyrifos, Malathion has been reported [65]. Increase in acetylcholine inhibits the release of gonadotrophin releasing hormone (GnRH) and that inhibits release of luteinizing hormone (LH) and follicle stimulating hormone (FSH). It results into inhibition of gametogenesis and steroidogenesis [66,67]. So, it is quiet likely that synthesis of testosterone being a steroid hormone may get hampered that could further result in erectile dysfunction. Pesticides like chlorpyrifos and carbofuran inhibit acetylcholine esterase [68,69]. Hence increased acetylcholine suppresses the reproductive functions [53–57].

6.3. Oxidative stress

Oxidative stress occurs when cells are exposed to excessive levels of reactive oxygen species (ROS) as a result of an imbalance between pro-oxidants and the protective mechanisms conferred by antioxidants [70]. ROS are formed during regular metabolism due to the univalent reduction of oxygen molecule. Superoxide (O^{2-}) is the most important among the ROS. Organophosphate induces production of ROS and hence causes reproductive tissue damage [71]. Atrazine and imidachloroprid is also responsible for oxidative stress by reducing levels of glutathione [59,60]. Hydrogen peroxide (H_2O_2), hypochlorous acid (HOCL), and peroxynitrite ($OONO^-$) are other important free radicals implicated in the pathophysiological mechanism of vascular disease. The vascularendothelium is the major source for these free radicals. Besides this, platelets and leukocytes are the other important sources of ROS [72]. Superoxide radicals are generated because of incomplete oxygen reduction in the electron transport system. Membrane bound enzymes, such as nicotinamide adenine dinucleotide hydrogenase–nicotinamide adenine dinucleotide phosphate hydrogenase oxidase, are the major source of superoxide radicals in activated phagocytic cells [73]. It has been reported that up regulation of these enzymes is associated with an increased risk of vascular disease [74,75]. Superoxide dismutase (SOD) is an important enzyme that removes the superoxide radicals from the human

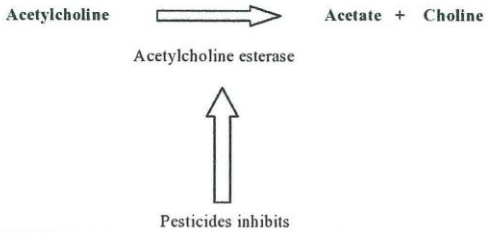

Figure 1. Inhibitory action of pesticides on Acetylcholine esterase.

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body. There are 3 types of SOD isoenzymes: cytosolic Cu Zn-SOD, mitochondrial Mn SOD, and extracellular SOD. Extracellular SOD reportedly plays a critical role in maintaining the redox state of vascular interstitium and thereby prevents the pathophysiological effects of superoxide in the vasculature. Extracellular SOD converts superoxide to H_2O_2.

The interaction between NO and ROS is one of the important mechanisms implicated in the pathophysiological process of erectile dysfunction [76]. NO interacts with superoxide to form peroxynitrite, which has been reported to play a central role in atherogenesis [72]. The stability of peroxynitrite allows a greater opportunity for it to diffuse through a cell to find a target. The unusual stability of peroxynitrite is due to its being folded into the &-conformation (Figure 2), which cannot directly isomerize to the much more stable form, nitrate [77]. Peroxynitrite reacts with the tyrosyl residue of proteins, which inactivates superoxide dismutase and leads to increased amount of superoxide [78]. This further increases the formation of peroxynitrite and reduces the available NO concentration. Peroxynitrite causes smooth-muscle relaxation and is less potent than NO. The effect of NO and peroxynitrite have been studied on stripped cavernosal tissue from rabbits [79]. They reported that relaxation induced by NO is short lived and immediate in onset compared with that due to peroxynitrite, which is prolonged and slow in onset. Moreover, the tissues returned to original tension immediately with NO, whereas with peroxynitrite, the tissues were unable to recover their original tension. These mechanisms ultimately produce an ineffective relaxation in cavernosal tissue, which produces erectile dysfunction shown in Figure 3.

6.4. Apoptosis and necrosis

The new findings are consistent with the well-known involvement Ca^{2+} in cell death from oxidative stress. Oxidative stress causes Ca^{2+} influx into the cytoplasm from the extracellular environment and from the endoplasmic reticulum [80]. Rising Ca^{2+} concentration in the cytoplasm in turn causes Ca^{2+} influx into the mitochondria and nuclei. In the mitochondria, Ca^{2+} accelerates the disruption of normal oxidative metabolism leading to necrotic cell death. In nuclei, Ca^{2+} modulates gene transcription and nucleases that control apoptosis (programmed cell death that involves fragmentation of DNA). Insecticides and pesticides has been shown to act as reproductive toxicants in male rats and histologically induce severe focal necrosis of the germinal cells in seminiferous tubules associated with tubular atrophy (shown in Figure 3). [81–83] NO interact with peroxide to form peroxynitrile. Peroxynitrite and superoxide have been reported to increase the incidence of apoptosis in the endothelium. This leads to denudation of endothelium and reduction of available NO [77,79]. Currently, the following are considered biomarkers of vascular endothelial dysfunction: insulin resistance, homocysteinemia, lipoprotein (a), endogenous nitric oxide (NO) synthesis inhibitors, vasodilators (nitrites, nitrates, and 6-keto prostaglandin F1a), adhesion molecules (vascular adhesion molecule-1 [VCAM-1], intercellular adhesion molecule-1 [ICAM-1], and P- and E-selectins), and thrombotic hemostatic factors [84]. Since, endothelium is made up of endothelial cells and these cells are responsible for NO production via eNOS. Superoxide is reported to have a direct vasoconstriction effect through mobilization of calcium ions [85]. This can potentially produce ED. According to the literature, the decreased availability of NO is the key pathophysiological process that leads to erectile dysfunction [86].

6.5. Endocrine disrupter

An endocrine disruptor was defined by the U.S. Environmental Protection Agency (EPA) as "an exogenous agent that interferes with the synthesis, secretion, transport, binding, action, or elimination of natural hormones in the body that are responsible for the maintenance of homeostasis, reproduction and developmental process" [87]. The pesticide, Glyphosate is a known or likely potential cause of endocrine effects [88]. There is already evidence that Glyphosate may act as an endocrine disruptor for both males and females by altering aromatase activity, estrogen regulated genes, and testosterone levels in rats [89] however Roundup has been reported to act via different mechanisms. Roundup exposure during pregnancy and lactation at a level that did not induce maternal toxicity in Wistar rats nevertheless induced adverse reproductive effects in male offspring, including decreased daily sperm production during adulthood, increase in abnormal sperms, and low testosterone serum level at puberty. In exposed female offspring, only a delay in vaginal canal opening was observed [90]. Pesticides disrupt level of different neurotransmitters and later these increased neurotransmitters effect the follicle stimulating hormone and luteinizing hormone by feedback inhibition [53–57,66,67].

6.6. Effect on leydig cells

Leydig cells are responsible for production of testosterone. These cells are under influence of luteinizing hormone (LH). Luteinizing hormone acts on enzyme cholesterol demolase

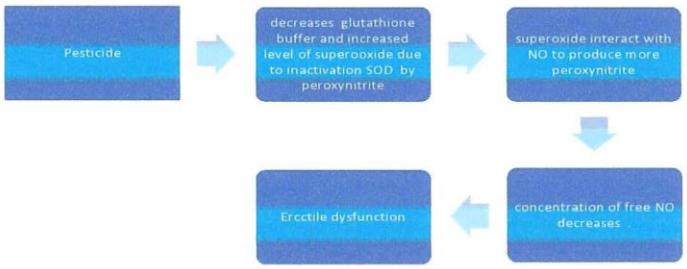

Figure 2. Pesticides causing oxidative stress.

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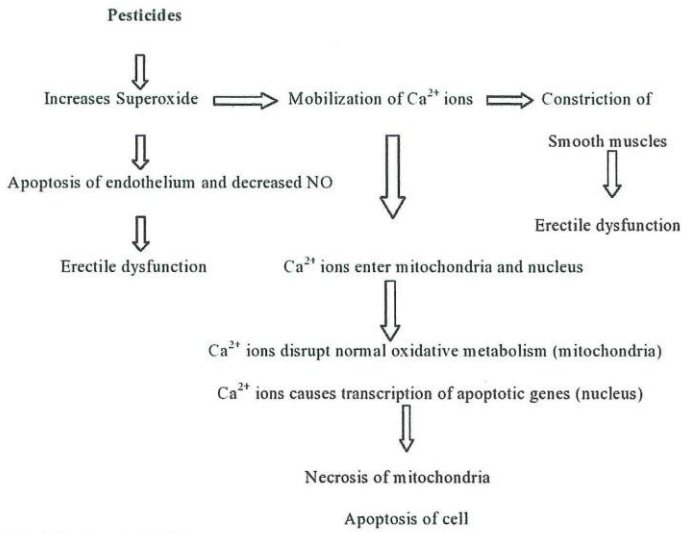

Figure 3. Apoptotic and necrotic action of pesticides.

activity which results in testosterone synthesis from cholesterol. Round exposure damages testosterone producing Leydig cells from mature rat testis at concentrations a tenth of agricultural use and beginning 1 hour after exposure [61]. Insecticide like atrazine, carbaryl and methoxychlor effects leydig cells. Metabolic products of methoxychlor downregulates the Cytochrome P450 enzymes, the enzymes involved in synthesis of testosterone [91].

6.7. Effect on testosterone and other hormones

Testosterone, the male hormone, is the major driver of male reproductive development and function. Suppression of its levels within the adult testis shuts down spermatogenesis the cause is unknown - and low sperm counts often show evidence of abnormal Leydig cells, which produce testosterone in the testis [92]. Dimethoate causes testicular damage, damage to sperm production & reduction in testosterone levels [93]. Glyphosate reduces production of testosterone [61]. At the very low, non-toxic concentration of 1 ppm, both Roundup and Glyphosate decreased testosterone level by 35%. It also inhibits production of other hormone [94]. Previous studies indicated that most insecticides inhibit the non-specific esterase activity in leydig cells that, in turn, result in reduced testosterone production [91,95]. Organophosphate is responsible for decreasing total serum testosterone and estradiol levels [96]. In fact, IMI acts as a nicotine acetylcholine receptor agonist and somehow likely to interfere with the release of gonadotropin-release hormone from hypothalamus and/or with release of LH/FSH from the pituitary (Figure 4), resulting in the reduction of sperm production in the testes [97]. Pesticides like, carbamates, pyrethroids, organophosphatases, Thio-and dithiocarbamates, chlorphenoxy acids and chlormethylphosporic acids reduces testosterone concentrations in male after acute exposure during exposure season [98]. Pesticides may also be involved in erectile dysfunction by altering levels of testosterone which functions as activator of enzyme nitric oxide synthase, enzyme responsible

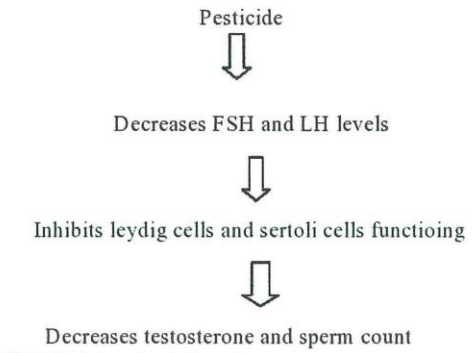

Figure 4. Action of pesticides on hormones.

for production of nitric oxide [99]. NOS are of two types iNOS and cNOS [100,101]. cNOS is calcium dependent and it has two isoforms i.e. eNOS (endothelial) and nNOS (neuronal) [102]. Nitric oxide synthases are responsible for the synthesis of nitric oxide from L-arginine [103]. Experimental evidence suggests that the constitutive isoforms of NOS may be responsible for NO production in penile erection [104,105]. Recently, several studies have revealed that nitric oxide (NO) is an important neural messenger which mediates penile erection [106–110]. Erection is mediated by the release of NO from non-adrenergic non-cholinergic nerve terminals, the endothelium of penile blood vessels, and corporal smooth muscle, producing smooth muscle relaxation and vasodilation [111]. NO stimulates the formation of guanylate cyclase in smooth muscle cells, converting GTP to 3′5′-cyclic GMP (cGMP) [111]. A cascade of cGMP-dependent intracellular events then leads to a decrease in intracellular calcium, ultimately causing smooth muscle relaxation, in part through changes in potassium conductance [111,112]. A recent study also hypothesized that androgens maintained and facilitated male

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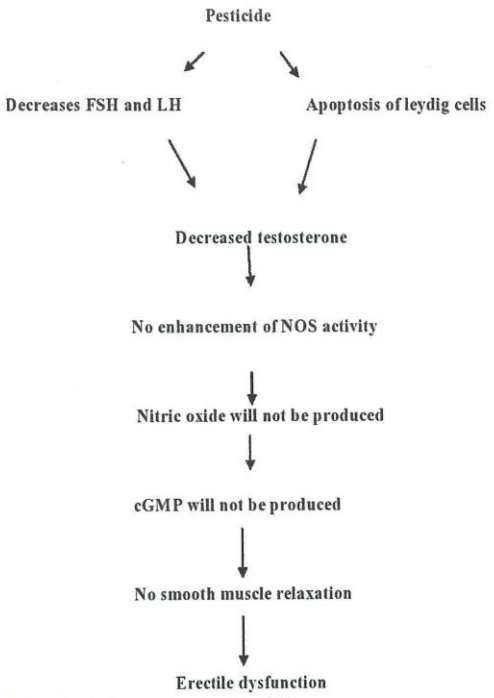

Figure 5. Mechanism of action of pesticides.

sexual potency through enhancement or maintenance of NOS activity in the corpus cavernous tissue in the penis [86]. Testosterone ensures penile erection through maintenance of nitric oxide synthase (NOS) activities in the peripheral nervous system and that deprivation of the androgen may reduce the number of corporal smooth muscle cells through apoptosis [113]. In addition, several studies have shown that androgen replacement facilitated neural activities in some areas of the brain which mediate sexual function [114,115]. Neurogenic NO is an important mediator of penile erection [116]. Hence indirect effect of pesticides occurs as shown in Figure 5.

6.8. Effects on tunica albuginea

The tunica albuginea is the tough fibrous envelope of connective tissue that surrounds the corpora cavernosa of ths penis. It consists of approximately 5% elastin, an extensible tissue that is primarily made up of the amino acids glycine, valine, alanine, and proline. The majority of the remaining tissue is collagen, which is made up of lysine, proline, glycine, alanine, and other amino acids [117]. The tunica albuginea is directly involved in maintaining an erection. On administration of imidachloroprid to the rats, the investigations revealed increased thickness of tunica albuginea [118]. Alterations in the microarchitecture of the tunica albuginea, including a decrease in the elastic fibers, may contribute to impotence in men [119]. Microstructural disorders of tunica albuginea have been reported in patients affected by impotence. In impotent patients, a reduction in the elastic fibers in the TA appears to produce disorders in the arrangement of the collagenic fibers. These alterations in the architecture of the TA in impotent patients can give rise top erection disorders [120]. During erection intracorporal pressure of patients with venogenic erectile dysfunction was significantly lower. Tunica albuginea collagen fibers exhibited degenerative and atrophic changes which presumably lead to tunica albuginea subluxation and floppiness. These tunica albuginea changes seem to explain cause of lowered intracorporal pressure which apparently results from loss of tunica albuginea veno-occlusive mechanism [121]. Atrazine also effects tunica albuginea. Atrazine increases thickness of tunica albuginea [70]. Tunica albuginea of patients showed degenerative and atrophic changes of collagen fibers; elastic fibers were scarce or absent [121].

6.9. Pesticides and neurotransmitters

Neurotransmitters are endogenous chemicals that transmit signals across a synapse from one neuron (brain cell) to another 'target' neuron. Decrease or increase in level of neurotransmitter effect the normal functioning of body. Different neurotransmitters like GABA when increased in body regulate FSH and LH in negative manner by suppressing release of Gonadotrophin releasing hormone. Hence suppress normal reproductive functions [53–57]. Acephate and metamidophos stimulate the secretion of hypothalamic corticotropin-releasing hormone, which in turn stimulate adrenocorticotropic hormone (ACTH) and so cortisol [49]. Receptor of cortisol are located on GnRH neurons, RFRP-3(mammalian ortholog of GnIH) and on gonadotrops. High cortisol level inhibits the secretion of GnRH, LH and testosterone while positively regulates RFRP-3 secretion, thus suppressing reproductive system [122]. Decrease in testosterone may be the reason of erectile dysfunction as testosterone is activator of nitric oxide synthase enzyme involved in production of nitric oxide [99].

The manuscript is suggestive of a significant place of erectile dysfunction as a causal factor for infertility. In this communication it is inferred that pesticides are having multiple mechanisms of action through which these chemicals cause erectile dysfunction. It is also reflected that out of mentioned widely used pesticides, acetamiprid is having most devastating effect causing erectile dysfunction as it acts through multiple inhibitory pathways.

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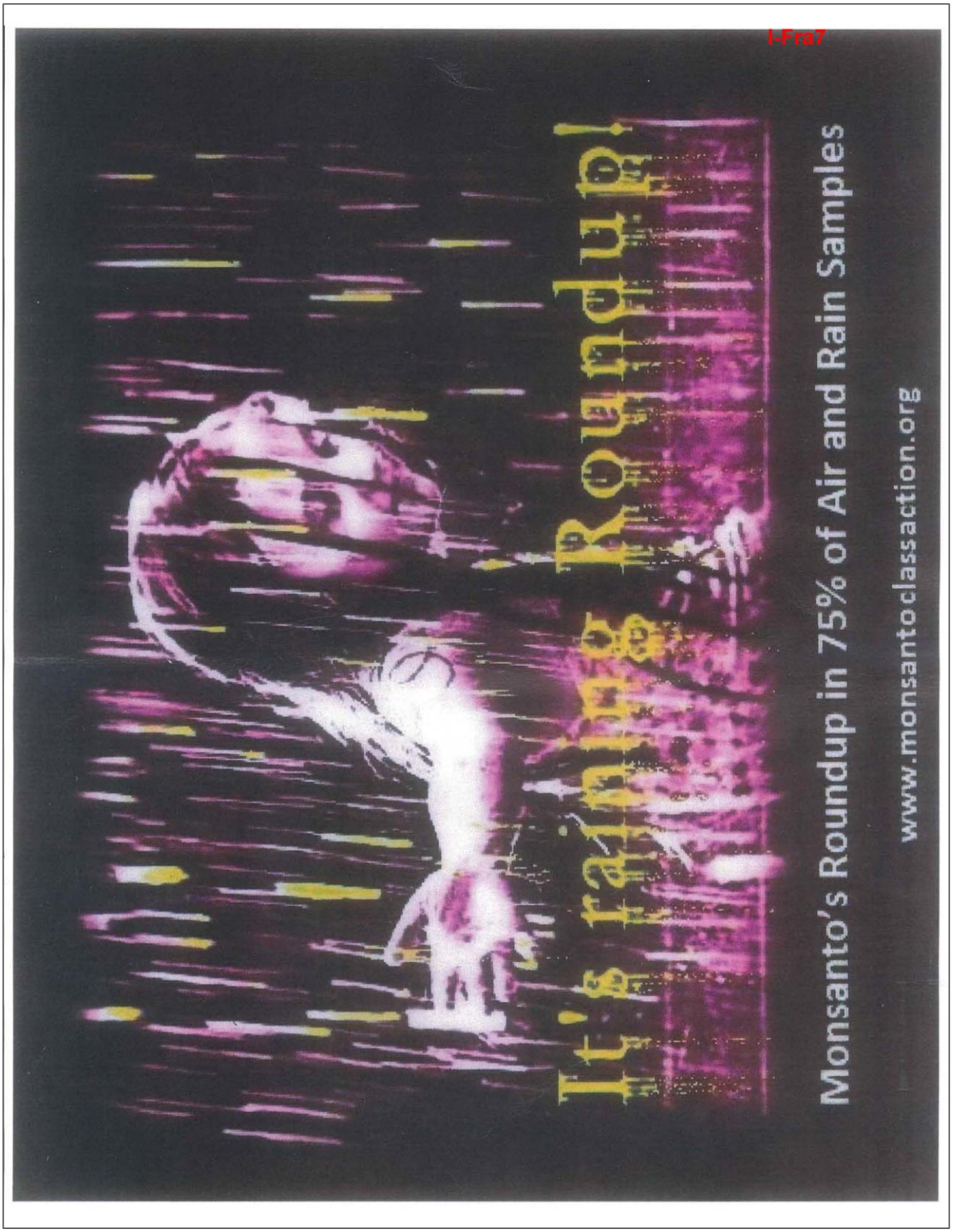
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Comment Letter I-Fra7 — Fraser, Mary

Response 1

The article is “Potential pathways of pesticide action on erectile function – A contributory factor in male infertility.” 2015. RP Kaur, V Gupta, AF Christopher, P Bansal*, Baba Farid Univ of Health Sciences Faridkot*, India.

The authors submit an extensive summary of their suggestion that erectile dysfunction is an important contributor to infertility. They proceed to correlate what they describe as the “indiscriminant use of pesticides” with infertility and then narrow their hypothesis to a few chemicals associated with pesticides.

The paper provides an exhaustive discussion of the possible causes of infertility with numerous examples of the dozens of ways that fertility may be impacted. The list of factors cited that “may” contribute to infertility is focused on erectile dysfunction (and not fertility). The authors inadvertently make a strong case for the impact of dozens of direct and indirect “confounding factors” on fertility.

Although the paper outlines more than a dozen physiologic and metabolic processes that may be involved in fertility, they inappropriately attempt to link “possible” causality to dozens of the processes discussed in their article. They fail to provide any substantive support to the secondary and tertiary links to pesticides. In fact, the authors fail to provide defensible arguments to primary exposures to pesticide or the links to the dozen mechanisms and processes they discuss. Throughout the paper they use words such as “infer”, “suggests”, “possible”, “quite likely” and numerous other unsubstantiated terms that fail to link their hypothesis to direct or confirmed pesticide exposure. After five pages of discussion, the authors state as their summary that “the review successfully highlights the indiscriminate regional use of pesticides” which does not link causality to their hypothesis. As a result, it is doubtful that this paper would be accepted for publication in the USA. Moreover, the active ingredients cited in the paper are not proposed for use in the District’s Integrated Vector Management Program (IVMP).

Furthermore, it should be noted that the District’s IVMP represents a tiered, carefully considered and focused approach to the surveillance and control of vector species, not the “indiscriminate regional use of pesticides.”

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Comment Materials I-Fra8 — Fraser, Mary

Response 1

The commenter provided a list of documents and an index by email but did not explain how they relate to the PEIR analysis. Therefore, no response can be provided or is required.

I-Joh

Comment from Dale Johnson

i have lived in Bolinas since Jan 3 1982.

This has not been a bad year for mosquitoes.
i want you to maintain the agreement you made with WestMarin citizens to consider our area ORGANIC which it is..spraying would destroy the organic farm certification. 1

DO NOT PUT SPRAY ON US...
Sincerely, Dale Johnson

Comment Letter I-Joh — Johnson, Dale

Response 1

For many years, the District has cooperated closely with organic growers and businesses throughout the Service Area. As a result, no adverse consequences to organic agriculture have been reported. As part of the Proposed Program, the District will continue its consultation and cooperation with organic growers and businesses. Vector control materials certified and labeled for organic use will be used as appropriate in conjunction with organic operations and accompanying organic operation plans.

The District uses several biorational formulations of mosquito larvicides that contain three bacterial active ingredients that are found in nature. Certain formulations containing these active ingredients are labeled for use with organic crops by the Organic Materials Review Institute and the US EPA. Examples of bacteria pathogenic to mosquitoes are *Bacillus sphaericus* (Bs), the several strains of *Bacillus thuringiensis israelensis* (Bti), and *Saccharopolyspora spinosa*. Two bacteria, Bs and Bti, produce proteins that are toxic to most mosquito larvae, while *Saccharopolyspora spinosa* produces compounds known as spinosyns, which effectively control all larval mosquitoes. Bs can reproduce in natural settings for some time following release. The Bti materials the District applies do not contain live organisms but only spores made up of specific protein molecules. All three bacteria are naturally occurring soil organisms that are also commercially produced for use as mosquito larvicides. These are the only three active ingredients approved for use in controlling larval mosquitoes when organic production is in progress.

One adult mosquito control product used by the District (Merus™ 2.0) is approved (by OMRI and the USDA National Organics Program) for use in conjunction with organic operations.

With respect to the issue raised by the commenter about chemical treatments for vector control in West Marin, the District operates under the terms of an agreement with a group known as the West Marin Mosquito Council (WMMC). The most recent version of the Agreement was approved by the District and WMMC in May 2016. The Agreement recognizes that the District may apply all the bacterial products discussed above, plus certain non-organic products, namely Agnique MMF, S-methoprene, and mosquito larvicide oils such as CoCoBear™.

As discussed initially in the PEIR Program Description (Section 2.3.5.1.1), Agnique MMF is a very thinly applied (monomolecular) film product that acts as a larvicide and pupicide. Similarly, mosquito larvicide oils such as CoCoBear™ are applied as larvicides and pupicides where needed and appropriate. The WMMC Agreement also permits the use of s-methoprene, a mosquito growth regulator discussed in the PEIR Section 2.3.5.1.1. In the geographical region referred to by the commenter (West Marin), s-methoprene is applied only when necessary to Onsite Wastewater Treatment Systems (OWTS), also known as septic systems, to control larval mosquitoes. Under the District's policies and practices, Agnique, s-methoprene and larvicide oils are always used judiciously and in such a manner as not to interfere in any way with organic agriculture or production.

I-Leg

Comment from Dan Legacy

Please stop spraying in West Marin. I 1

Dan Legacy
Bolinas

Comment Letter I-Leg — Legacy, Dan

Response 1

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I-Per

Comment from Michael Peri

We are adverse to any chemical spraying in West Marin. We support organic alternatives, and will do all in our power to bring conscious solutions to the table. 1

Comment Letter I-Per — Peri, Michael

Response 1

The District uses several biorational formulations of mosquito larvicides that contain three bacterial active ingredients that are found in nature. Certain formulations containing these active ingredients are labeled for use with organic crops by the Organic Materials Review Institute and the US EPA. Examples of bacteria pathogenic to mosquitoes are *Bacillus sphaericus* (Bs), the several strains of *Bacillus thuringiensis israelensis* (Bti), and *Saccharopolyspora spinosa*. Two bacteria, Bs and Bti, produce proteins that are toxic to most mosquito larvae, while *Saccharopolyspora spinosa* produces compounds known as spinosyns, which effectively control all larval mosquitoes. Bs can reproduce in natural settings for some time following release. The Bti materials the District applies do not contain live organisms but only spores made up of specific protein molecules. All three bacteria are naturally occurring soil organisms that are also commercially produced for use as mosquito larvicides. These are the only three active ingredients approved for use in controlling larval mosquitoes when organic production is in progress.

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I-Spe

Comment from Suzanne Speh

I live [redacted] in Inverness Park, though I believe technically my address is in Point Reyes Station. Last year I wrote a letter to Cicely Muldoon at Point Reyes National Seashore about my concerns with the huge mosquito problem we were having (I have copied the text of that e-mailbelow). I believe she contacted the mosquito district at that time.
This year the mosquitos have been MUCH less of a problem. I saw that you were asking for public comment prior to October 1st and that is the reason for this e-mail.
I would like you to take whatever steps necessary to keep the mosquito population in this area to a minimum. I feel that your studies will yield solutions that have the lowest environmental impact - you are the experts. I support your recommendations. I do NOT support keeping all chemicals out of West Marin at the expense of not being able to leave my house six months out of the year due to an excessive mosquito population. 1

Thank you

Suzanne Speh
[redacted]

Hi Cicely

When the park was originality planning the conversion of the Giacomini pasture to wetlands, many of us were concerned with the potential for an out of control mosquito population, The first few years were great and we thought we had been worried for no reason. Last year was a little worse, but this year is a nightmare. I live [redacted] in Inverness Park. I frequently walk to Point Reyes in the morning for yoga. We are also in the process of purchasing a second property on Laurel Street. I cannot go outdoors, even in the middle of the day, without being eaten alive by mosquitos. I can no longer walk to Point Reyes because I get so many bites while walking along SFD and the path by White House pool that it drives me right out of my mind - dozens of bites and right through my clothes. I can't garden - just went out for a few minutes to harvest beans for dinner and got at least a half dozen bites. Everyone I talk to who lives or has cause to be on or near properties near the Inverness Park side of the wetland agrees that it has become miserable. I can no longer enjoy my property or the surrounding outdoors. I hope the Park can figure out some way to abate this problem or living here is going to become impossible. It's really not fair as we were here long before the wetland.

Sincerely
Suzanne Speh
[redacted]

Comment Letter I-Spe — Speh, Suzanne

Response 1

The commenter notes that she observed high numbers of mosquitoes and aggressive biting during 2014. She also complains of the partial loss of enjoyment of her property and of the pain caused by multiple bites when outdoors. She suggests that the mosquitoes may be originating from the former pasture land that was converted to wetlands as part of the Giacomini Wetland Restoration Project. The commenter notes that the mosquito populations were lower during the subsequent year (2015).

The commenter's assertions are supported by the observations of District staff during this timeframe and data generated by the District's mosquito surveillance program. It should be noted that the land in question is under the jurisdiction of the National Park Service, specifically the Point Reyes National Seashore. The commenter includes a letter that she sent to the Superintendent of the National Seashore, complaining about the problem. During this 2014 period, District staff also received telephone calls and service requests from other residents of this area.

Although the District periodically conducts surveillance for mosquito species and abundance under a Scientific Collecting Permit, the District is not authorized to conduct mosquito control operations on these federal lands. However, during the design phase of the wetland restoration project, District staff provided technical advice intended to minimize the potential for production of mosquito species (physical control – source reduction measures) referenced by the commenter and collected in the District's mosquito traps.

As the commenter notes, the Point Reyes National Seashore, which employs biologists, is responsible for control of mosquitoes on its property. Although the District enjoys a cooperative working relationship with Seashore staff, it lacks the authority to take direct action to reduce mosquito populations. Annual and seasonal fluctuations in mosquito breeding and populations are normal for the type of wetland, where the potential for mosquito production is high.

During 2014, at the request of the US Fish and Wildlife Service, a District staff member traveled to Bandon, Oregon, to provide technical advice in the case of a newly restored wetland that produced salt marsh mosquitoes (e.g., *Aedes dorsalis*) in extremely high numbers. This type of mosquito can travel up to 20 miles to find a blood meal, and the situation became so dire that the nearby town was featured on the national news for several weeks until the problem was remedied. The Bandon Marsh problem was described in the PEIR in Section 15.4.2 No Chemical Control Program as an example of what can happen when there is no chemical control in a habitat restoration area adjacent to urban development.

The commenter requests that the District not refrain from the use of chemical means to reduce what she cites as excessive mosquito populations. It should be noted that in the locality described by the commenter, due to the jurisdictional issue described above, the District is unable to apply all the components of its full Integrated Vector Management Program, particularly chemical means of mosquito control, on National Park Service lands.

However, the District will provide mosquito surveillance and control in relation to private and public properties in the Inverness area and respond to service requests. The District also attempts to assist residents and visitors to this area and encourage mosquito source reduction through the education and outreach components of the IVMP. This is accomplished via the distribution of brochures, fact sheets, newsletters, participation in local events and fairs, presentations to community organizations, newspaper and radio advertising, public service announcements, social media postings, District website postings, and contact with District staff in response to service requests.

5 Public Hearing Comments and Responses

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T-San Rafael

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MARIN/SONOMA MOSQUITO AND VECTOR CONTROL DISTRICT

Public Review and Hearing of
Draft Programmatic Environmental Impact Report (PEIR)
For the Marin/Sonoma Mosquito and
Vector Control District's
Integrated Vector Management Program

SCH#2012052066

SAN RAFAEL COMMUNITY CENTER

618 B STREET

SAN RAFAEL, CALIFORNIA

TUESDAY, SEPTEMBER 15, 2015

Reported by:

Julie Link

CALIFORNIA REPORTING LLC
(415) 457-4417

T-San Rafael

APPEARANCES

Philip D. Smith, District Manager

Susan Hootkins, Senior Consultant

Public

Mary Fraser

T-San Rafael

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T-San Rafael

SAN RAFAEL, CALIFORNIA

TUESDAY, SEPTEMBER 15, 2015 6:42 P.M.

--o0o--

MS. HOOTKINS: So at this point in the meeting, I'm going to open it for the public hearing, and Mary Fraser, would you please come forward.

MS. FRASER: Hi, Good evening, ladies and gentlemen. Is this on? I suppose you can hear me anyway.

My name is Mary Fraser. I'm the mother of three children, and as the mother I had the unfortunate experience of having one of my children spend 35 days in the intensive care unit. Now, because of that experience I've become very well educated on health risks to children, and one of the areas that I've become very proficient in is pesticides and herbicides in general. So I want to share with you a little bit of my knowledge about pesticides.

Now, pesticides is an umbrella term. It includes under the umbrella insecticides, herbicides, and fungicides, so that's the three classes of life we have on this planet. And the end root of pesticide, "cide" in Latin means

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death, so we have death to plants, death to animals, and death to fungi. 1

Many people think that a more apt term for pesticides is ecocide, death to the environment.

Now, pesticides are regulated by the EPA, and pesticides have what are called active ingredients and inert ingredients and adjuvants. The only part of a formula of a pesticides that is tested is the active ingredient. The inerts and the adjuvants are not tested. So when you combine these together, you have a toxic formulation of completely unknown toxicity because the complete formula has never been tested. 2

So I'm here today to urge you to not use any herbicides or insecticides unless the complete formulation has been tested, which to my knowledge has never happened except with the case of Roundup.

And Roundup, I'm not sure if you're familiar with it, but the main ingredient in Roundup is glyphosate. The World Health Organization just declared glyphosate to be cancer causing to animals. They labeled it their highest classification, Classification 1. They labeled it as a probable human carcinogen only because they 3

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did not have enough data for humans.

You know, it's unethical to conduct human trials to induce cancer, so they had to use the tests that were done, particularly on agricultural workers, and they said the data is just too fuzzy so we can only give it a classification of 2A.

Now, when pesticides are formulated with the EPA, the inerts can be declared proprietary business information or trade secrets, so those ingredient do not have to be disclosed to the public. And as I said before, the complete formulation is not tested.

Once these formulations are created they're oftentimes patented, and in order to test the patented formulation you have to get the permission of manufacturer. Fat chance of doing that.

With glyphosate, which is of real concern because it's been labeled a probable human carcinogen and it does cause cancer in animals, the patent has run out, and that complete formulation has been tested by a group of scientists in France, and they've found that the complete formulation was a thousand times more toxic than the active ingredient alone,

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glyphosate.

So, you know, you have to ask, well, what's a thousand times more toxic than cancer in animals? 5

Well, the cancer rate we have in this country right now is one in two for men, one in three for women. Cancer is now the number two killer of children.

There was an article that came out today on the web that Harvard University has done a meta analysis on pesticides and they have conclusively linked pesticide use to cancer in children. 6

So I understand in your program you have an option of no chemical use. I would highly recommend that you do that to protect the health of our children, to protect our own health. 7

I mean, glyphosate has been used in this country for over 20 years. It completely saturates our food.

Farmers have learned to use it on crops right before harvest because what it does is it induces death in the plant in its last gasp for life, which is to procreate. It comes to full fruit. Because it's typically applied during the harvest or right before harvest which is a couple 8

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days before it's actually harvested, the herbicide actually does not have a chance to get down to the roots, it just goes into the fruit of the crop.

So what we're having is a huge increase in glyphosate residues in food, but unfortunately none of our government agencies test for that.

I find that really incredible since glyphosate is the most heavily used herbicide in our country that no government agency tests for the residues in our food.

Now, glyphosate in its parent product, Roundup, is used on genetically modified foods. The crops are specifically designed to be Roundup ready and that's typically corn, soy, canola, cottonseed, alfalfa, yellow squash, and now they've come up with genetically modified potatoes and apples.

The crops that are Roundup ready are designed specifically to withstand heavy applications of this herbicide, and that's particularly corn and soy.

So you find genetically modified ingredients in about 80 percent of the processed foods in this country, but we don't test for the residues of this cancer causing ingredient, which

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I find just absolutely appalling. 9

So, you know, what you can do, actually, is you can get yourself tested for glyphosate now. There's a program through Moms Across America and Sustainable Pulse where for $119 you can get yourself tested. I would recommend you do that, especially if you're an applicator, because what they're finding is that the higher the levels of glyphosate in your body, the more you have a tendency for chronic disease. 10

Now, cancer has a latency period typically of 15 to 20 years, so it's difficult to tell, you know, how soon your cancer may show up with your exposure to glyphosate. There are scientific studies that say that glyphosate induces cancer in the range of parts per trillion, and someone explained to me that a part per trillion was about one drop of water in two Olympic swimming pools. And again, we don't test for glyphosate in our food.

So glyphosate is legal to be sprayed on 160 different crops. They're particularly using it on wheat, so it's being sprayed on wheat right before harvest. 11

So what we're finding as a society is that

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we have a lot of celiac disease, or what people consider gluten intolerance.

There are scientists out of MIT, particularly Dr. Stephanie Seneff and Dr. Anthony Samsel that will tell you that, no, you don't have celiac disease or gluten intolerance, you're actually being poisoned by glyphosate. 11

Dr. Nancy Swanson, a retired Navy physicist, has done an analysis of the data of the use of glyphosate on our main crops. She used data from the CDC, from their hospital discharge and death rates. She correlated it with the amount of application of glyphosate on our crops, which has continued to escalate every year, and she has come up with a causation of 35 chronic diseases and deaths. 12

Now, I spoke with Dr. Don Huber, who is a professor emeritus of plant pathology at Purdue University. He looked at this data, he uses it in his slide show. He says this is not correlation, this is causation when you see this kind of data.

So we are essentially poisoning ourselves with glyphosate. I would ask that any herbicides that you use, because glyphosate is particularly used as an herbicide, not contain that ingredient. 13

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Glyphosate is formulated in 700 different products, including AquaMaster, Roundup, there are many more that public agencies typically use. 13

I'm probably at the end of my three to five minutes.

I haven't had a chance to review the 532-page document. I do intend to do it and to submit written comments in particular.

I guess I would like an opportunity to ask some questions. One of the questions -- some of the questions that I have is, are you going to be doing aerial spraying? 14

Because I went to a fund raiser recently for the people that sued over the Brown Apple Moth spraying, if you remember that, several years ago. And the lead attorney, Stephan Volker, in that suit, stood up and publicly stated that when they went to trial and the state was asked to produce evidence of economic harm, which was the justification for that program, the state could not produce any. 15

So that was an intended aerial spraying throughout the Bay Area. It did happen down in Monterey County. Apparently there were several people that suffered severe effects from the

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spraying that did happen, including a baby, a young woman, and several other people.

Now, because they settled those cases and in the settlement, you know, there are restrictions on not discussing these things publicly, Mr. Volker was not at liberty to discuss the details of those settlements. 15

So I am extremely suspicious of any aerial spraying that you're going to do. What I'm finding is that there seems to be some kind of -- I don't know, I think this is a terrible word to use, but a conspiracy between chemical company, pesticide applicators, people who spray aerially, that they find things to spray for, you know, particularly in the Brown Apple Moth spraying. 16

And one of the questions I have is about this West Nile Virus is, are you going to be spraying aerially for that? And what are you going to be spraying? And has all the components of that spray been tested completely by an independent laboratory?

Because that's the other thing, that's the other dirty little secret about the EPA and pesticides, is that the active principal, when it's tested it's only tested by the manufacturer, 17

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because the EPA has closed ten out of its twelve labs.

The EPA doesn't do any independent testing. That's complete bullshit.

So as you can tell, I'm fairly emotional about this. I'm very passionate about it.

In my family -- and I do not come from a farm worker family and I do not live in an agricultural zone -- both of my parents have cancer. Out of four nieces and nephews, two of them have autism. The third one has chronic digestive difficulties, which is an indication of glyphosate poisoning. And all three of my children have asthma. And I can relate pesticides to all of those illnesses.

So please, stop using pesticides, stop using herbicides. Until we have a functioning EPA that actually regulates them, that actually tests them, that tests the complete formulation so that we actually know what we're doing instead of spraying toxic substances that are completely unknown in their toxicity.

I mean, we're finding pesticides in breast milk now. We're finding it in urine.

U.S. Geological Survey did tests in

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Illinois, Mississippi, Iowa, and they found Roundup in 75 percent of the air and rain samples. That means it's raining pesticides.

I just find that incredible in a democracy that I'm being unwillingly poisoned. Seventy-five percent of the air and water samples. 18

They're finding it in urine, virtually in everyone's urine.

They're finding it virtually all tap water. We're almost completely contaminated.

And when you talk to Dr. Don Huber, whose spent his lifetime talking about glyphosate, looking at the problems with it, he says that in some soils it's got a 20-year lifespan, depending on the structure of the soil. 19

Now, a lot of public agencies will use glyphosate and its attendant formulations as what they call fire control. They say, well, we need to reduce the weeds because they'll burn.

Well, if you talk to the people who are specialists in this, they'll tell you that actually it increases the risk of fire, because what it does is it spreads through the root systems of the plants, and so it reduces the plant's ability to withstand drought, and so they 20

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become more flammable.

Dr. Don Huber will tell you that it increases sudden oak death.

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He was here recently. He's been in the Bay Area twice now to talk about glyphosate. The next time I hope you all go to see him. He's published a lot of information on the Web.

I'd like to quote him for a minute, and I don't know that I'll get this quote exactly, but what he says is he finds that historians when they look back on this period of history, it won't be that they'll talk about the number of pounds of pesticides that we've sprayed, but how willing, how utterly willing we were to sacrifice our children for the profits of corporations.

Thank you.

MS. HOOTKINS: Okay. Do we have anyone else who wishes to speak tonight, any more cards? I'm looking for Don. No? Okay. Okay.

Well, I'm going to -- I'm not going to completely close the public hearing because someone might come in late, so we will suspend our presentation and discussion until we see if anyone else comes by 8:00 o'clock tonight.

So we can take a break. Thank you.

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(Off the record 6:58 p.m. to 7:30 p.m.)

MS. HOOTKINS: Okay. It's 7:30 and no one else is here to speak, so at this point the public hearing is adjourned.

(Adjourned at 7:30 p.m.)

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REPORTER'S CERTIFICATE

I do hereby certify that the testimony in the foregoing hearing was taken at the time and place therein stated; that the testimony of said witnesses were reported by me, a certified electronic court reporter and a disinterested person, and was under my supervision thereafter transcribed into typewriting.

And I further certify that I am not of counsel or attorney for either or any of the parties to said hearing nor in any way interested in the outcome of the cause named in said caption.

IN WITNESS WHEREOF, I have hereunto set my hand this 28th day of September, 2015.

Juliana Link
CER-830

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TRANSCRIBER'S CERTIFICATE

I do hereby certify that the testimony in the foregoing hearing was taken at the time and place therein stated; that the testimony of said witnesses were transcribed by me, a certified transcriber and a disinterested person, and was under my supervision thereafter transcribed into typewriting.

And I further certify that I am not of counsel or attorney for either or any of the parties to said hearing nor in any way interested in the outcome of the cause named in said caption.

IN WITNESS WHEREOF, I have hereunto set my hand this 28th day of September, 2015.

Terri Harper

Terri Harper
Certified Transcriber
AAERT No. CET**D-709

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Hearing Transcript T-San Rafael **September 15, 2015**

San Rafael, California

Response 1

Pesticides are selective in action. The intensive laboratory testing required by the USEPA is to determine and delineate the specific toxic effects to target plants and animals and the relative safety to other nontarget species.

Response 2

Inert is the definition of a material that is known to have no effect, especially no adverse effects. Although there are numerous adjuvants used in some pesticide formulations, most are surfactants (soaps, etc.) added to increase the ability to effectively treat the target. However, over the past years, many product formulations (both the active and inactive ingredients) have also been tested by USEPA, and the results are included in the Federal Register as they are developed.

Response 3

This statement is factually incorrect. The World Health Organization (WHO) classification for glyphosate is 2-A and even that designation is tenuous due to the lack of credible supporting information used to make this determination. See Response I-Fra3-2 and Response O-VOL-22 on the WHO report.

Response 4

While it is correct that some formulations that include inert ingredients are not listed completely, it is because these formulations are proprietary and the result of considerable research by the company producing the product. However, it is also true that only inert additives are used in these cases, as USEPA requires the identification of any known toxic materials used.

Response 5

This statement is factually incorrect. The WHO classification for glyphosate is 2-A and even that is a tenuous designation due to the lack of credible supporting information used to make this determination. The toxicity suggested here is for direct immersion exposure to petri dish cells. See Response I-Fra3-2 and Response O-VOL-22 on the WHO report.

Response 6

The causality of cancer is still unknown. It is not statistically possible to attribute causality to exposures for most reported incidents, as there are numerous confounding factors that are also involved in these reports. Anything can be correlated to incidence of cancer, but correlation is not causality. The dependence of exposure to pesticides to incidence of cancer in humans is nearly impossible to quantify in any scientifically defensible study. The report indicated is not listed for evaluation. However, this article was reviewed by Dr. Williams (see his resume as Attachment B to Response to O-VOL-15), who did not find it to be a convincing or adequately supported statement of effect. The article suggests that young children who are exposed to insecticides inside their homes may be slightly more at risk for developing leukemia or lymphoma during childhood, according to a meta-analysis, which does no more than identify a number of possible causes. The authors suggest that much more work needs to be done. http://www.hsph.harvard.edu/news/hsph-in-the-news/pesticide-exposure-in-childhood-linked-to-cancer/

Nothing in the cited article changes any of the analysis or conclusions in the Draft PEIR regarding the possible human health or ecological effects of the District's use of glyphosate.

Response 7

The No Chemical Program requires complete reliance on other methods that can be more disruptive to the environment than chemical control depending on the application site and habitat/species present. A "no chemical option" allows for unacceptable growth of unwanted vector populations with environmental consequences for human and animal health. A No Chemical Program alternative is addressed in Section 15.4.2 of the PEIR.

Response 8

These comments are factually incorrect statements. Glyphosate has been used safely for dozens of years to increase crop yields that support our population (and many others worldwide). The Food and Drug Administration (FDA) and other US and foreign agencies routinely test for residues in foodstuff and crop production and are tasked to report and remove any contaminated food items. This process also triggers a revision to tests required and proof by the manufacturer that the issue has been resolved before the product is allowed on the market. Although there have been no substantiated correlations to glyphosate exposure in foods to cancer in humans, the FDA has indicated that it will begin to add glyphosate to its current list of residue tests in major crops such as soybeans and corn. The District does not use, and does not propose to use, glyphosate on food crops. Further comments that raise concerns about glyphosate use on food crops are not relevant to the Program or PEIR analysis of the District's proposed use of glyphosate for vector control.

Response 9

These comments are also a factually incorrect series of statements. Glyphosate has been used safely for dozens of years to increase crop yields that include many products that are designated as genetically modified organisms (GMO) in which the crop is selectively developed for resistance to some pests and some pesticides. Because this provides a selective herbicide action to weeds when GMO crops are used, there is little to no adverse impact to the crop. Much of the public concern about the term GMO has been elicited by the media and others who do not understand the science or process of GMO. There have been genetically modified crops since the early botany experiments by Mendel in the 1880s. The FDA and other US and foreign agencies routinely test for many types of residues in many crops, including GMO crops.

Response 10

The latency of cancer after exposure, in most cases, is said to be several years, according to some researchers and based on possible modification of basic, but complex physiological and enzyme systems. These links, however, are not clear and are always accompanied by numerous other confounding factors that may contribute to the responses.

Response 11

There is no credible evidence that celiac disease and gluten intolerance are linked to pesticides. The research and articles by Stephanie Seneff and Anthony Samsel have been challenged by dozens of practicing scientists due to inappropriate correlative assumptions and invalid data evaluations. Their papers have been retracted due to a lack of credible conclusions. See Response I-Fra3-2.

Response 12

The statement that the work by Nancy Swanson provides a clear causation rather than correlation is faulty. The "confirmation" of causality by Don Huber at Purdue is based on his use of a secondary limited correlation in which he suggests that comparing national lists of diseases and deaths to national use information for glyphosate is not scientifically defensible. There is no way to determine what the actual

exposures to the individuals have been regardless of, or based on, the amount of chemical used. In scientific terminology, this type of correlation is an example of a false analogy.

Response 13

Given the magnitude of historic use of glyphosate products, it would seem likely that there would be relationships suggesting exposure results in adverse effects to humans, but this is not the case. Even in the data provided in support of the recent WHO designation of hazard, the most critical reviews of that finding by world renowned scientists and practicing toxicologists indicate no scientifically defensible causality between glyphosate and adverse effects or cancer. See Response I-Fra3-2 and Response O-VOL-22.

Response 14

Aerosol applications are explained in detail in Section 2.3.5.1 with subsections for mosquito larvicides and mosquito adulticides and specific explanations of fogging from the ground or possible spray applications from aircraft. Aerial spraying whether from the ground using backpack equipment or truck mounted equipment, or from watercraft or aircraft, is generally considered in response to potentially severe threats to the environment or public health from a large population of mosquitoes or when the treatment area is too large for the other chemical treatment or nonchemical treatment methods or when special-status species could be disrupted by walking into the wetlands or using motorized equipment in a relatively large area.

Response 15

The comment is on the LBAM eradication project by CDFA, not the District's PEIR. No response is required.

Response 16

Every product used by the District, regardless of the application technique, has been tested and approved (regulated) by the USEPA or other agency. WNV is controlled chemically by using larvicides in water where mosquito-breeding is determined from surveillance and by adulticides for knocking down the adult mosquito when treatment criteria are met regarding the size of the mosquito population and proximity to humans. These methods and the specific chemicals used for each are described in Section 2.3.5.1 of the PEIR and evaluated for ecological and human health impacts in Sections 6.2.7 and 7.2.7, respectively, based on Appendix B, Ecological and Human Health Assessment Report. It is the adult mosquito that actually transmits the WNV disease to humans, birds, and other animals. See Response 14 above.

Response 17

These statements are factually incorrect. USEPA conducts additional in-house reviews and additional in-house and contracted testing of the products in the registration process to validate or challenge the results submitted by the manufacturer. In fact, the manufacturer has no control over the testing by USEPA and must completely revise or modify its proposed product if the USEPA determines the data cannot be corroborated. Dr. Williams (see resume) was director of a chemical and product testing laboratory for the USEPA during his tenure at the agency and provided numerous independent studies on chemicals in the registration process.

Response 18

The statements by the commenter are incorrectly attributing personal experience with diseases to glyphosate poisoning. There is no corroboration of these claims, and they are not supported by the body of scientific literature relating to health effects of glyphosate. The comments contain a number of inaccurate and/or unsubstantiated statements that are contrary to the evidence in the PEIR or cannot be evaluated, including the comments that the "pesticides are not tested", and "we do not know their toxicity"

and that "75% of the air and rain samples in mid-western states contain Roundup", "all tap water contains glyphosate", and "it is in everyone's urine."

Response 19

Soil characteristics modify the lifespan of every chemical introduced to the soil. In most cases, the modification results in reduction of the toxicity of a chemical and renders it less toxic. Glyphosate breaks down in soils according to pH and several other soil characteristics.

Response 20

The District does not manage vegetation for fire control, thus this is statement is not relevant to the Program or PEIR. In any event, reduction of vegetative fuel available to support fires has been shown to reduce the impact of wildfires and urban fires associated with excess vegetation fuel.

T-Santa Rosa

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MARIN/SONOMA MOSQUITO AND VECTOR CONTROL DISTRICT

Public Review and Hearing of
Draft Programmatic Environmental Impact Report (PEIR)
For the Marin/Sonoma Mosquito and
Vector Control District's
Integrated Vector Management Program

SCH#2012052066

WELLS FARGO CENTER FOR THE ARTS

50 MARK WEST SPRINGS ROAD

SANTA ROSA, CALIFORNIA

THURSDAY, SEPTEMBER 17, 2015

Reported by:

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SANTA ROSA, CALIFORNIA

THURSDAY, SEPTEMBER 17, 2015 6:24 P.M.

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MS. HOOTKINS: Okay. We're opening the public hearing, and our first speaker is Mary Fraser, F-r-a-s-e-r.

Mary.

MS. FRASER: Thank you. Good evening, ladies and gentlemen. My name is Mary Fraser. I am a licensed real estate broker, a resident of Marin, and the mother of three children.

As the mother of three children, I had the unfortunate of experience of having one child land in the intensive care unit for 35 days. Because I never, ever want to repeat that, I have educated myself very well on public health and personal health issues.

About three years ago I became very interested in the issue of pesticides in human health and I've been looking at it extensively.

I also come from a large family of attorneys, so everything, virtually everything that I'm going to say tonight is backed up by scientific studies. And I brought a copy of just some of the studies that I'm going to talk about.

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I did submit written comments, they were emails that I sent in today. I did not get any acknowledgement that they were received, so I came today to make sure that the four emails that I sent are on public record. 2

So I attended the presentation two nights ago, and I wanted to talk about my concerns with this process.

I do not think you've been given adequate time or notice of these hearings and their content. You published a legal notice only on August 28th and you expect the public to be able to read and prepare comments no later than October 2nd on a document that's over 500 pages. 3

You made the document available in libraries in CD form. Most libraries have reservation systems in order to use a computer, and time is limited to one hour per reservation, and to print out any pages is a ten-cent fee per page.

All of this combined makes for great difficulty in reading and analyzing your draft EIR.

I'm requesting that you extend the official notification period to at least 120 days; 4

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that you take out quarter-page display ads in newspapers; and that you send notifications of the draft PEIR to multiple NGOs and nonprofits.

I would also like you to supply copies of the draft PEIR to interested individuals at no charge. I understand you want $500 for it.

I have not had adequate time to analyze your PEIR as I am employed. 4

Now, I attended your public hearing on September 12th [sic] and I watched a PowerPoint presentation that I found a little bit misleading.

The presentation stated that you use chemicals approved for organic food production and that you consulted beekeepers. 5

During a very brief review of the draft PEIR, in my one-hour computer time allotted at the public library, I found that you propose to use glyphosate.

This is a chemical pesticide that is not allowed in organic food production. The World Health Organization, through its research arm, the International Agency for Research on Cancer, has declared glyphosate to be carcinogenic to animals, and it gave glyphosate a '1' rating, which is their highest rating for animals, and a '2A' 6

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rating for humans.

Now, in reviewing the draft PEIR, I noted that the information on glyphosate is inaccurate in the following ways.

Section 4.6.2.3, Human Toxicity. And I'm quoting here from your document.

"The shikimic acid pathway, which is specific to plants and some microorganisms; therefore, glyphosate is thought to have very low toxicity to mammals," and they quoted USEPA 1993.

This is very old information, it's 23 years old. Dr. Stephanie Seneff of MIT and Anthony Samsel have found that the shikimic pathway is present in bacteria in the human gut. And I have supplied in my email a copy or a link to their peer reviewed published paper.

Now, Dr. Seneff and Anthony Samsel have published numerous other articles about glyphosate, and I've attached four other articles, including one that specifically deals with wildlife and has a co-author by the name of Judy Hoy.

Now, glyphosate is rarely used alone, it's almost always used in combination with inerts and adjuvants.

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A team of independent scientists did studies on the complete formulation of Roundup, which is the most widely used pesticide that has glyphosate as its main ingredient or active principle. The testing found that the complete formulations had toxic levels that were up to a thousand times more toxic, and I'm supplying the links to two of those studies.

One is titled *Major Pesticides are more Toxic to Human Cells than their Declared Active Principles.* One of the lead scientists on that team was Dr. Seralini.

The other article is entitled *Ethozylated Adjuvants of Glyphosate-based herbicides are Active Principles of Human Cell Toxicity.*

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In Section 4.6.2.3 it's stated, "Currently, no published scientific evidence indicates that glyphosate is carcinogenic or mutagenic."

I'm attaching a copy of the WHO report that disputes this, and it labels glyphosate as carcinogenic to animals and a probable human carcinogen.

I don't know why this PEIR -- or this report from the World Health Organization has not

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been included in the draft PEIR. The initial release was in March 2015 and the entire monograph was released in July 2015. There have been numerous media reports about the World Health Organization finding.

Now, in Section 4.6.2.1 there's a table of the degradation of glyphosate. Monsanto, the manufacturer of glyphosate, has been sued by both the State of New York and the country of France over falsely advertising that their product, Roundup, which has glyphosate as its active principle, is biodegradable.

The country of France won their case, even though it was appealed to the highest court in France, and the State of New York settled the case with Monsanto.

The actual degradation of glyphosate is dependent on the chemical nature of the environment it is in. In some cases it can take 20 years or more to biodegrade. So your table in there on the biodegradation of glyphosate is inaccurate.

I'm asking that you not use glyphosate at all, and I want the directors of the District to approve the no chemical option that's proposed in

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your draft PEIR. 11

I also supplied another email with a copy of a speech that I recently did called *Why Pesticides should be Banned.* At the end of the speech I have included all of my references. I think I have -- actually this didn't print out. There should have been 13 references in this thing. I guess I'll have to recopy that and send that to you again. 12

Now, another issue in terms of choosing the no chemical option for your draft PEIR is that pesticides drift, so you cannot guarantee anyone that they will not -- that you will not affect them.

Pesticides get into our air and our water, and in this email I attached a speech that I recently wrote about pesticides drift and their threat to the $45 million organic agricultural market in Marin. 13

And I want to share this graphic with you because not only is glyphosate -- not only has it been sued by the country of France and the State of New York, but now there's a class action lawsuit against it, and this is one of their graphics. 14

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It's a little girl playing in the rain and it's saying "It's raining Roundup." And underneath it says, "Monsanto's Roundup is found in 75 percent of air and rain samples."

Now, this graphic comes from an official government study done by the United States Geological Survey. They've done a number of studies. The lead author on most of the studies is a Paul Capel.

In my documents that I've submitted I believe I have referenced at least four of his studies because they've tested the air in at least four states and this is a consistent finding. And not only do they find Roundup in the air, they find atrazine, they find malathion, they find Diazinon and a number of other chemicals.

Again, I urge you to use the no chemical route. I'm going to go through your PEIR and see if you actually address physical alternatives to using chemicals, and I will be sending you comments on that.

And I sent you another email about where pesticides, and in particular glyphosate, have been banned because countries and municipalities around the world are starting to ban it.

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In Marin County the Marin Municipal Water District recently chose to exclude the use of pesticides from the 26,000 acres that they manage. This is a continuation of a nine-uear hiatus in the use of pesticides, because no one wants pesticides in our water supply. Unfortunately, they're already there in many places. 17

Now, Richmond, California has banned pesticides. This effort was led by two doctors, one of whom is the retired chief of cardiology at Kaiser Permanente. His name is Dr. Jeff Ritterman. He wrote and published an extensive article outlining the public health reasons for banning pesticides. 18

I had the privilege to hear Dr. Ritterman speak recently. He started his talk by saying that the compelling evidence against pesticide use was the birth defects that are showing up in South America. We're talking about babies born with no skulls or half a skull, babies born with no arms and no legs, babies born with one big Cyclops eye.

These are defects that are nearly identical to the ones that happened in Vietnam after we defoliated that country with Agent Orange during the war. And we have yet to ban the entire 19

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formula of Agent Orange. We've only banned 2,4-T; we still use 2,4-D on our agriculture. 19

So in Argentina, because the health consequences have been so severe, 30,000 doctors have called for a ban on pesticides -- 30,000 doctors.

In El Salvador, 20,000 men have died in the last five years because they started using pesticides in the sugar cane fields. So in El Salvador they've banned 32 different pesticides. 20

Sri Lanka has the same issue. Thousands are dying from end stage kidney disease, and one of the reasons that they have such terrible kidney disease is because they have serpentine soil. And we have serpentine soil in Marin. So Sri Lanka has banned a number of pesticides.

France has banned them. The Netherlands has banned non-commercial use. German ministers are calling for a ban in the entire European Union. All of these countries operate on the precautionary principle where chemicals have to be proven safe before they can be used. 21

In America we have the opposite policy. Chemicals undergo minimal testing by the manufacturer, and then the public has to prove 22

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that a chemical is unsafe before it can be forced off of the market. This can take decades and has untold consequences. 22

So again, I'm asking you to use the no chemical option in your EIR. 23

And I've attached a list of all the other places where pesticides have been banned or restricted, including the City of Fairfax, California; the City of Belvedere, California; the City of Sausalito, California, where pesticides are under review; the Reed School District in Tiburon, California where pesticides are not used on school district grounds; the Larkspur Corte Madera School District in Corte Madera; the Mill Valley School District; Connecticut, where pesticides are banned on municipal playgrounds; New York, where again they're banned on school grounda; Bermuda, Brazil, where the chief prosecutor wants glyphosate banned; 24

And the country of Columbia. They've banned the spraying of glyphosate for use on illicit crops. They used to spray for the crops that created cocaine, but the health damages were so severe that they've stopped doing that. 25

Besides Richmond, California, we have 26

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Chicago, Illinois; Tacoma Park, Maryland; Laguna Hills, California; Durham, Connecticut; Paris, France; the University of Vermont Law School; and Emory University campuses; Santa Barbara, California; Plainville, Connecticut; Santa Fe, New Mexico; and San Francisco has had an 85 percent reduction in the use of pesticides based on their IPM Policy. 26

So now I want to talk a little bit about bees because bees are pollinators, mosquitoes are pollinators.

We're spraying for mosquitoes. You cannot discriminate between pollinators in your pesticide applications. 27

I was looking through some old files the other day -- or today actually, because I've been interested in bees for quite awhile, and I came across a file from 2013, the Winter Loss Survey done by a group called The Bee Informed Organization, and they had a graphic here that I want to submit.

Where in 2013 they had a 30 percent mortality rate on honeybees over the winter. In their graphic they say that an acceptable range, a sustainable range is 15 percent. 28

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Now, we're at 50 percent loss. So in two years we've gone from 30 percent loss to 50 percent loss in our honeybees. These are just in the pollinators that we really count. **28**

Pollinators pollinate almost 90 percent of the plants in this world. If we lose our pollinators, we lose most of our food crops. We're left with corn, wheat, rice, a few other things that are pollinated by the wind.

We can't survive on that because there are not enough essential amino acids.

I mean, to have a 20 percent increase in two years. I have read a statement by a bee scientist that said that we are one hard winter away from not having any food. We do not have food security in this country. **29**

I find that absolutely unbelievable and unacceptable. And for you to spray to kill pollinators when we have this kind of critical situation in this country is absolutely unjustifiable. Absolutely unjustifiable.

Now, in your presentation you say you consult with beekeepers. I want to quote from a book that was written by a Dr. Evangelos Vallianatos. He was with the EPA for 25 years. **30**

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This is a whistleblowing book, it's called *The Secret History of Pollution and the EPA*, it's entitled *Poison Spring*. It just came out recently.

I had the privilege to be the driver for Dr. Vallianatos recently, and we talked extensively about pesticides and the EPA, and he's the one, and his book, that talked to me extensively about the fact that inerts are never tested along with the active principle, it's in his book here. 30

But really what I want to talk about is beekeepers. He says, "For several decades honey producers in the United States have worried that protesting the death of their bees would bring down the wrath of industrial farmers who will either wipe them out with sprays or ruin them by suggesting that honey and pollen may be full of tiny capsules of nerve gas and numerous other poisons. 31

"This explains a depressing Catch-22. Even as their bees continue to die, honey producers have been largely silent. They're willing to lose some of their hives as the price for the social contract they have with the farmers

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whose insecticides kill their bees." 31

Apparently, there are number of pesticides that are microencapsulated. They're still on the market. The bees will pick up the pesticides in their microencapsulation and take them back to the hives. So you buy commercial honey, you may be buying a product full of pesticides. 32

Here's another quote from the book. There was a woman, D. Lusby, who sent letters about this to the EPA, and the author Dr. Vallianatos says, and I quote from his book, "I talked to Lusby in July of 1989. She told me that beekeepers who complain about pesticide poisoning paid a price. Farmers would spray bomb their hives, sometimes killing all the bees. Such was the cost of this war that few beekeepers dared to go public with their grief and loss. This remains true today." 33

So the last time I spoke I talked about the cancer rate, because I think that's the real public health issue here. It's not malaria. I don't think it's the West Nile Virus. I think it's the cancer rate. 34

Because according to the American Cancer Society, we have a 2015 rate of one in two for men and one in three for women. I just find that

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astronomical.

We used to have a one in ten rate, and now we have one in three and one in two. That's pretty unbelievable. That's the real public health issue. 34

Let me go back to glyphosate for a minute because one of the documents I submitted was a study done by Dr. Nancy Swanson and other scientists. It was published in the *Journal of Organic Systems*. It's called *Genetically Engineered Crops; Glyphosate and the Deterioration of Health in the United States of America*.

The abstract says, "A huge increase in the incidence and prevalence of chronic diseases has been reported in the United States over the last 20 years. The herbicide glyphosate was introduced in 1974 and its use is accelerating with the advent of herbicide tolerant genetically engineered crops. 35

"Evidence is mounting that glyphosate interferes with many metabolic processes in animals and plants, and glyphosate residues have been detected in both.

"Glyphosate disrupts the endocrine system and the balance of gut bacteria. It damages DNA 36

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and is a driver of mutations that lead to cancer."

Now, the endocrine system is our hormonal system, and this is particularly damaging to children who have critical windows of development, and what we're finding is huge increases in chronic diseases in children.

We now have an autism rate that's somewhere between one in fifty and one in sixty-eight, and Dr. Swanson and Dr. Seneff have directly tied glyphosate to autism.

So in this paper that Dr. Swanson did with three other scientists, they published a number of graphs on the chronic diseases, and I believe there's something like 32 of them.

Let's see; stroke, diabetes, obesity, lipoprotein metabolism disorder, Alzheimer's, senile dementia, Parkinson's, Multiple Sclerosis, autism, inflammatory bowel disease, intestinal infections, end stage renal disease, acute kidney failure, cancers of the thyroid, liver, bladder, pancreas, kidney, and myeloid leukemia.

And they published these graphs and they find a correlation that they say in the end that it's not correlation, that statistically when you look at this it's actually causation.

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And that's a statement that's been verified by Dr. Don Huber. He's a professor emeritus of plant pathology at Purdue University. He spent 41 years in the United States Army as a colonel. His specialty is biological warfare. And Dr. Huber spends his time now, he's about 80 years old, campaigning against glyphosate. 37

So let me share a couple of these slides with you. I've shared the entire thing as a link. 38

What's of particular concern right now besides the autism rate is the link to dementia, because there have been recent reports in the press that there is an upcoming epidemic of dementia in 40- and 50-year-old people.

So here a couple of their graphs. 39

The red line is the glyphosate applied to corn and soy. The blue is the percentage of corn and soy planted. And then the yellow bars are the liver cancer that's incident, and you can see how closely it tracks. The same with age adjusted kidney and renal pelvis cancer.

Because glyphosate is a patented antibiotic. Dr. Huber states that it affects the bees because the bees pick up the glyphosate from the rain. It gets into their gut, it disrupts 40

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their gut biome, and so they literally starve to death.

So again I ask you not to use chemical warfare against pollinators. We need our food, we need our children. We need our health.

Cancer is the big public issue.

So once I review your entire PEIR, I will be submitting additional documents, additional data.

I intend to send your PEIR to Pesticide Action Network, to Beyond Pesticides.

And let me just close with one other study that I find really interesting, and this gets a lot of attention from men.

Published in the *Asian Pacific Journal of Reproduction*. It's called *Potential pathways of pesticide action on erectile function. A contributory factor in male infertility.*

And the abstract says, "One of the important objectives of this manuscript is to focus on the place of erectile dysfunction as an important factor for infertility. The review is about correlating the indiscriminate use of pesticides and to find out and highlight the evidences from mechanism of action of these

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pesticides for erectile dysfunction, and find out the most used and most dangerous pesticide from an erectile dysfunction point of view.

"The review suggests that erectile dysfunction is having a significant place as a causal factor for infertility.

"The study infers that pesticides are having multiple mechanisms of action through which they cause erectile dysfunction."

So I didn't send the link for this, I will just leave it with my written comments.

There are a number of other studies which I will provide about male impotence, infertility.

Dr. Huber told me in private conversation that the fertility rate in this country has dropped 30 percent in the last five years.

My daughter worked at a fertility center. She was the egg donor coordinator. She quit the job. She told me, "Mom, we can't find enough egg donors. The girls aren't healthy enough. They're still showing up to donate their eggs, but they're just not healthy enough."

My goal in life is to have healthy grandchildren. I can't do that if you all continue to put toxic chemicals into the air and

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the water to kill our pollinators. 43

Thank you.

MS. HOOTKINS: Okay. Well, I think we're going to go ahead and we'll wait. (inaudible) because some of these people want to have something to eat. (inaudible).

Yeah, let's put the public hearing in suspense until -- yeah.

(Off the record 6:49 p.m. to 7:15 p.m.)

MR. SMITH: Seeing no further attendees, we'll close at 7:15.

MS. HOOTKINS: The public hearing is closed.

MR. SMITH: 7:15, yeah, nobody here.

(Adjourned at 7:15 p.m.)

--o0o--

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REPORTER'S CERTIFICATE

I do hereby certify that the testimony in the foregoing hearing was taken at the time and place therein stated; that the testimony of said witnesses were reported by me, a certified electronic court reporter and a disinterested person, and was under my supervision thereafter transcribed into typewriting.

And I further certify that I am not of counsel or attorney for either or any of the parties to said hearing nor in any way interested in the outcome of the cause named in said caption.

IN WITNESS WHEREOF, I have hereunto set my hand this 28th day of September, 2015.

Juliana Link
CER-830

CALIFORNIA REPORTING LLC
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T-Santa Rosa

TRANSCRIBER'S CERTIFICATE

I do hereby certify that the testimony in the foregoing hearing was taken at the time and place therein stated; that the testimony of said witnesses were transcribed by me, a certified transcriber and a disinterested person, and was under my supervision thereafter transcribed into typewriting.

And I further certify that I am not of counsel or attorney for either or any of the parties to said hearing nor in any way interested in the outcome of the cause named in said caption.

IN WITNESS WHEREOF, I have hereunto set my hand this 28th day of September, 2015.

Terri Harper

Terri Harper
Certified Transcriber
AAERT No. CET**D-709

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Hearing Transcript T-Santa Rosa **September 17, 2015**

Santa Rosa, California

Response 1

Comment noted. No response is needed.

Response 2

The four emails are included in the Final PEIR as Comments I-Fra1 through I-Fra4. The same ones provided as hard copy are included as I-Fra6.

Response 3

The comments on the CEQA review process were also made in written comments I-Fra3. See Response I-Fra3-1 (i.e., comment letter I-Fra3, response 1).

Response 4

The extension of time to 120 days was not granted. See Response I-Fra3-1.

Response 5

See Response I-Fra3-2 on the District's use of materials for vector control that are compatible with organic farming. District staff work cooperatively with the Beekeeper's Association and individual beekeepers. Staff take appropriate precautions in conducting District operations to minimize any potential for negative impacts to bee populations.

Response 6

The commenter makes several points about glyphosate. We agree it is not approved for use on organic farms. Concerning the WHO report, see Response I-Fra3-2.

Response 7

The commenter suggests that the PEIR's information on glyphosate is inaccurate and relies on old information. The fact that a study was performed in 1993 does not make it invalid. Moreover, the body of information for the registration of glyphosate has been submitted to the USEPA in dozens of studies, first by the manufacturer and its university and contractor scientists. The suite of studies required for approval include dozens and dozens of potential acute and chronic tests to detect possible effects to mammals (as surrogates for humans as well as for wildlife), birds, invertebrates, and bees. The research test data submitted to the USEPA is an ongoing process required for its Re-registration Eligibility Decision (RED) in which label changes and use patterns are reviewed and updated.

The studies cited for Seneff and for Samsel are generally based on meta-analysis computer models that compare effects and pesticide uses at the national or regional level. These studies are not relevant to the District's use of glyphosate in specific applications for vector control. Other reports by these authors have been discounted, and some have been retracted due to negative review and critique.

See Responses I-Fra3-3 and other responses to your email (comment I-Fra3) addressing the articles provided.

Response 8

There are numerous pesticide products that include inert and/or chemically different additives to enhance the spray characteristics, adhesion properties, and efficacy. Many of those products have been specially tested for toxicity and registered with the USEPA for specific vector control purposes (National Park Service 2016). Although some of these mixture products have been associated with increased toxicity, numerous studies have demonstrated that the increase in toxicity may be due to a surfactant additive. In most instances, these special formulations of pesticide products are intended to reduce the potential for adverse effects or to specifically be used for aquatic environments, e.g., a glyphosate product, Accord, is a formulation of glyphosate which has been shown to be safer to aquatic wildlife than some of the other formulations of glyphosate (Brodman et al. 2010). Many of the studies that report increased toxicity with adjuvants are conducted at the cellular level, which is not relevant to District uses. See Response I-Fra3-4.

Each of the active ingredients and adjuvants applied by the District were evaluated individually with consideration of pesticide's mode of action, persistence in the environment, toxicity, and environmental fate. Furthermore, the District's methods for application of the material, such as ULV techniques, were also considered. Based on this evidence and expert analysis, the Draft PEIR concludes that the vector control chemicals would have less-than-significant impacts to surface water and groundwater when applied consistent with the vector control application techniques, label requirements, and BMPs implemented by the District. See also Response O-VOL-29.

Response 9

The commenter is referring to Section 4.6.2.3 in Appendix B, which was prepared in June 2013. Since then, additional studies have been reviewed including the WHO report, which was published in 2015. The WHO report is the result of a "panel discussion" by the International Agency for Research on Cancer (IARC) about the potential for selected chemicals and products that have achieved some level of public interest and concern but may or may not be supported by the data and information available. In fact, the IARC has been challenged by dozens of technical experts who evaluated the process used by the panel to list glyphosate as a probable carcinogen. It has been demonstrated that IARC rejected the 800 studies / 3,000 documents that gave glyphosate a positive safety result, basing their decision of "probably carcinogenic" on only eight studies, of which three actually included results, and these results were arguably insignificant. See Response I-Fra3-5.

After the WHO publication listing glyphosate as a probable carcinogen, dozens of practicing scientists in the mainstream scientific community (including European Food Safety Administration, the German Federal Institute for Risk Assessment (BfR) and the lead author of one of the studies used by IARC to draw its conclusions) have criticized and disputed the results of the IARC for using a poor methodology and conducting inadequate research. The conclusions drawn by the IARC about the potential adverse effects of glyphosate were based on studies that are not relevant to actual, potential exposures and on studies that were based on high exposures to cells in petri dishes and *in vitro* laboratory conditions. See also Response O-VOL-22.

Response 10

For decades, scientists have demonstrated and validated that every organic chemical has a physical/chemical degradation characteristic termed "half-life" (a metric used to describe the elapsed time for a chemical to reach ½ of its initial activity). Each organic chemical, whether toxic or not, decays in both activity and toxicity over time. For some chemicals, the half-life can be hours, days, or weeks. By design, few chemicals used as pesticides1 have half-lives greater than a week and are further degraded by the

[1] The term "pesticides" includes herbicides used for destroying weeds and other unwanted vegetation.

environmental conditions of the application area. When pesticides get into soil, or water, or are taken up by plants and animals, their half-life characteristics are altered. The environmental fate of pesticides depends on the physical and chemical properties of the pesticide, particularly the pH of the medium, modifying how likely it is to travel through soil (soil mobility), how well it dissolves in water (water solubility), and how likely it is to become airborne (volatility).

Once a pesticide has been released into the environment, it can be broken down by exposure to sunlight, (photolysis), exposure to water (hydrolysis), exposure to other chemicals (oxidation and reduction), microbial activity (bacteria, fungi, and other microorganisms), and other plants or animals (metabolism). Glyphosate is an herbicide that is relatively stable to chemical and photo decomposition. The primary pathway of glyphosate degradation is soil microbial action, which yields the minimally toxic breakdown product AMPA and glyoxylic acid. Both products are further degraded to carbon dioxide. Glyphosate adsorbs tightly to soil so that its residues are relatively immobile in soil (USEPA 1993). This characteristic results in the chemical (when it is in the soil) being less available as a route of exposure and would require direct ingestion of the soil or sediment, which is not a likely route of uptake by associated biota.

See Response I-Fra3-5 on the degradation of glyphosate and also Response O-VOL-21.

Response 11

The commenter asks that no chemicals be used; she supports the No Chemical Program. This comment will be considered by the District's Board of Trustees in its consideration whether to approve the Program as proposed, or with modifications.

Response 12

The commenter references a speech she gave to Toastmasters that was provided separately and called Comment I-Fra2 in this Final PEIR. See Response I-Fra2-2.

Response 13

The email she references is included in this Final PEIR and identified as Comment I-Fra1. The District minimizes the potential for drift from larvicide and adulticide applications by following the best management practices listed in Response I-Fra1-1 in addition to meeting all label requirements. Also see Response I-Fra1-2 and Response O-VOL-24.

Response 14

The reports cited in this comment are addressed in Response I-Fra2-3. The reports include monitoring of air and rain associated with agricultural crop pesticide applications in Mississippi and other states. The data are not relevant to the District's pesticide applications.

Response 15

See Response 11 above.

Response 16

The commenter provided a speech that she gave to the Marin County Board of Supervisors in which she argued against the use of various pesticides, followed by lists of places where glyphosate or other pesticides are restricted (an email Comment I-Fra4 in this Final PEIR). Comments are noted and considered, although they are not directed to the District or its PEIR. See Response I-Fra4-2.

Response 17

Comment noted. See Response I-Fra4-2. No further response necessary.

Response 18

The reference cited is a recollection of a talk given by a third party and cannot be reviewed without the scientific basis for the claims by the cited person.

Response 19

This comment pertains to the effects caused by "agent orange," (2,3,7,8, TCDD or dioxin) a material that is not typical of the classes of pesticides used by the District. Every chemical has specific effects to biota and the impacts are based on the large variations in stereotypy, classification of action, active sites, and physiochemical characteristic at the time of exposure, among others. Dioxin is not used or proposed for use by the District.

Response 20

The comment cites information about diseases and deaths in various countries and suggests that the cause of the mortality and morbidity is a result of pesticide use in these countries. The comment also states that pesticides are being banned in South America and Sri Lanka, and other nations. Without the publications and specific information, no further comment can be made about these statements, which do not address pesticide use by the District for vector control. It should be noted, however, that in South America and many other nations, there are few restrictions on the use of pesticides, so it is difficult to put these claims in perspective compared to the rigorous regulations and safety testing imposed on uses of pesticides here in the US.

Response 21

Pesticides must undergo rigorous laboratory testing (and field trials) prior to registration for use in the USA. The commenter asserts that the countries cited use the Precautionary Principle to prove that chemicals are safe, which is said to be the opposite of the US. This is factually incorrect and uses a faulty concept to suggest that the chemicals are not safe. In fact, the Precautionary Principle is a flawed approach to any scientific evaluation, as it requires that one prove that no response to an action will occur. This is virtually impossible and is rejected by the credible scientific community. To those with scientific training, this suggests that one must "prove a negative," which is essentially impossible in any statistical sense of a defensible scientific process. See also Response O-VOL-22.

Response 22

This comment on testing and use is not a true statement. The USEPA requires that all pesticides undergo rigorous laboratory testing (and field trials) prior to registration for use in the US. Continuous review is conducted of pesticides listed in the EPA registry; and if/when an issue is identified, the chemical must re-enter the registration process and satisfy the testing requirements that address the specific issue identified. This is the Re-Registration Decision (RED) and is provided for public review when completed.

Response 23

See Response 11 above.

Response 24

The commenter lists cities and locales (including schools) that have banned pesticides. Concerning Marin County, see Response I-Fra4-2. The District cooperates closely with school districts and individual schools when conducting vector control operations in the vicinity of school premises.

Response 25

Commenter lists another locale that has banned pesticide use on illicit crops. No response is necessary, because this example is not relevant to District pesticide applications.

Response 26

See Response 25 above.

Response 27

The commenter suggests that the District cannot prevent inadvertent contamination of bees as a result of its use of pesticides for vector control. Of the many products available, those used by the District are applied using strict BMPs that reflect an understanding of and adherence to guidance designed to minimize effects on bees. These procedures include additional recommendations limiting pesticide use only within the wind speed parameters on the product labels conditions. The guidance and the BMP approach is tailored to minimize the potential for direct bee exposure to any of the pesticides used for vector control by the District. Furthermore, the District uses the following BMP H12 for pesticide applications that is contained in Table 2-6 in Section 2.9: which states that:

> "Do not apply pesticides that could affect insect pollinators in liquid or spray/fog forms over large areas (more than 0.25 acres) during the day when honeybees are present and active or when other pollinators are active. Preferred applications of these specific pesticides are to occur in areas with little or no honeybee or pollinator activity or after dark. These treatments may be applied over smaller areas (with hand held equipment), but the technician will first inspect the area for the presence of bees and other pollinators. If pollinators are present in substantial numbers, the treatment will be made at an alternative time when these pollinators are inactive or absent."

See also Response O-VOL-26.

Response 28

The commenter cites generally inaccurate statistics on the number of bees and bee colonies that are active in the US. Although several articles about the bee populations and the impact of pesticides on bees have appeared in the media, most are inaccurate, unvalidated claims without actual supporting data. Recently, the media reports about pesticide impacts to bees have focused on the neonicotinoid class of pesticides, which have been blamed for bee deaths and colony collapse disorder. Although the District does not use neonicotinoid products, a discussion of the potential contribution of these products to cumulative impacts on pollinators, including possible Colony Collapse Disorder, was included in the PEIR because it is relevant to their potential role in a cumulative impact discussion. Similar arguments that support the lack of toxicity of many pesticides to bees and other pollinators also pertain to the use of glyphosate. See also Response O-VOL-26.

Response 29

The commenter provides statements that the food supply will dwindle without pollinators/bees. Of course this is correct in concept, as bees and other pollinators are an integral part of the ecosystem process and have an important niche in the food production and crop status in every country. However, the District does not "spray to kill pollinators." In fact, data suggest that bee numbers are stable, and bee colonies are not adversely impacted to dangerous levels as asserted in the comment (NASS 2016).

Response 30

The District has routinely consulted with beekeepers in response to public service requests. There are numerous pesticide products that include inert and/or chemically different additives to enhance the spray characteristics, adhesion properties, and efficacy. Many of those products have been specially tested for toxicity and registered with the USEPA for specific vector control purposes (National Park Service 2016). Although some of these mixture products have been associated with increased toxicity, numerous studies have demonstrated that the increase in toxicity may be due to a surfactant additive. In most instances, these special formulations of pesticide products are intended to reduce the potential for adverse effects or to be used specifically for aquatic environments, e.g., a glyphosate product, Accord, is a formulation of glyphosate which has been shown to be safer to aquatic wildlife than some of the other formulations of glyphosate (Brodman et al. 2010). Many of the studies that report increased toxicity with adjuvants are conducted at the cellular level, which is not relevant to District uses.

Each of the active ingredients and adjuvants applied by the District were evaluated individually with consideration of pesticide's mode of action, persistence in the environment, toxicity, and environmental fate. Furthermore, the District's methods for application of the material, such as ULV techniques, were also considered. Based on this evidence and expert analysis, the Draft PEIR concludes that the vector control chemicals would have less-than-significant impacts to surface water and groundwater when applied consistent with the vector control application techniques, label requirements, and BMPs implemented by the District. See also Response 8 above and Response O-VOL-29.

Response 31

The commenter states that bee keepers are afraid to complain about their loss of bees and hives. In fact, much of the bee production has shifted to mobile hives that are used to service specific crops and fruits for a fee and are then moved to a new location. This has made it difficult for the USDA to monitor the status of bees and bee colonies. Bees are an integral part of the ecosystem process and have an important niche in the food production and crop status in every country. See Response 29 above.

Response 32

Encapsulated pesticides are generally incorporated into the soil furrows as the chemical is applied. This comment is not relevant to the District's chemical control operations.

Response 33

These stories of war between farmers and bee keepers are not typical, and no verification is provided. See Response 31 in which the use of hives for rent is now a large business. This comment is not relevant to the District's chemical control operations.

Response 34

The commenter addresses a clear public health issue about cancer but does not address the PEIR. The District has important responsibilities to protect human and animal health from existing and future vector-borne diseases such as WNV and Lyme disease, and from discomfort including allergic reactions, within the two-county Service Area. Another commenter on the PEIR indicated the following (Comment I-Spe):

> "I would like you to take whatever steps necessary to keep the mosquito populations in this area to a minimum. I feel that your studies will yield solutions that have the lowest environmental impact - you are the experts. I support your recommendations. I do NOT support keeping all chemicals out of West Marin at the expense of not being able to leave my house six months out of the year due to an excessive mosquito population."

Response 35

The commenter suggests that glyphosate interferes with metabolic processes to result in sublethal or chronic diseases and relates the national use of glyphosate to a general increases in diseases.

Although the term sublethal effect is often misused outside the scientific community, it defines the effects of a stressor (pesticide in this case) that is less than mortality. It includes evaluation of the potential effects on physiological and behavioral systems that may occur over time or result in a deficit of a physiological function. Although important in the determination of the potential adverse impacts of the pesticide, it is the "endpoint" most susceptible to confounding, outside, environmental factors. Adverse effects that are categorized as sublethal are also often confused with the concept of chronic effects, which include low level effects that are continued over long periods of time and usually associated with constant exposures to a stressor. Because this condition is not typical of District vector control applications of chemical products (generally single or intermittent localized applications), it is not relevant to the evaluation of District use of pesticides or herbicides. Unless the relationships of exposure and disease onset are directly shown in individuals, this comment is not valid scientifically.

Response 36

The comment states that glyphosate disrupts the endocrine system and then provides several "possible" links to chronic diseases and other health effects. Although glyphosate is one of the hundreds of chemicals on the USEPA list of chemicals to be evaluated as a potential endocrine disruptor, this designation has not been finalized. Thus, it is not reasonable to declare that adverse health impacts are likely from glyphosate acting as an endocrine disruptor. Therefore, the comment is not supported by our current understanding of any potential for glyphosate endocrine effects.

Response 37

Comment noted. The commenter's statement that Dr. Don Huber is campaigning against glyphosate does not provide support to the cited work by Dr. Nancy Swanson.

Response 38

Comment noted. The link was not spelled out and was not provided at the hearing. No response necessary.

Response 39

The graphic is not available to review as it is part of the commenter's verbal presentation. The correlations assumed by her statements, however, do not provide actual causality. Correlation is not causality unless a direct link to an individual is provided. The only handouts provided to District staff at the

hearing were a study of pesticides and erectile dysfunction (included previously as Comment I-Fra7), copies of emails addressed as Comments I-Fra1 through I-Fra4, a graphic entitled “It’s raining Roundup!,” and a graphic with a quotation from Prof. Huber. The hard copy emails and the two graphics were combined into Comment I-Fra6.

Response 40

The connection between glyphosate and bee injury mentioned in this comment is not verified, although the pathway of exposure is potentially complete. Dr. Huber is providing a hypothesis without verification. It is a flawed connection and correlation not supported by any data provided to the District; therefore, no further response is possible.

Response 41

The paper referenced here was published by the Asian Pacific Journal of Reproduction, and is focused on erectile dysfunction and provided in this Final PEIR as Comment I-Fra7. The only reasonable conclusion made by the authors is that they demonstrated that erectile dysfunction is a problem (with no conclusions about causality).

The authors submit an extensive summary of their suggestion that erectile dysfunction is important in fertility. They then proceed to correlate the “indiscriminant use of pesticides” with this dysfunction and then narrow the hypothesis to a few chemicals associated with pesticides. The paper provides an exhaustive discussion of the possible causes of infertility with numerous examples of the dozens of ways it may be impacted. The list of factors that “may” contribute to infertility is focused on erectile dysfunction (not fertility as the focus), which exemplifies the unstructured and indefensible argument in their prime hypothesis. The authors inadvertently make a strong case for the impact of dozens of direct and indirect “confounding factors” on fertility.

Although the paper outlines more than a dozen physiologic and metabolic processes that may be involved in fertility, they inappropriately attempt to link “possible” causality to dozens of the processes discussed, and they fail to provide any substantive support to the secondary and tertiary links to pesticides. In fact, the authors do not provide defensible arguments to primary exposures to pesticide or the links to the dozen mechanisms and processes they discuss. Throughout the paper they use words and phrases such as “infer”, “suggests”, “possible”, “quite likely” and numerous other unsubstantiated terms that fail to link their hypothesis to direct or confirmed pesticide exposure. After five pages of discussion they state as their summary that “The review successfully highlights the indiscriminate regional use of pesticides,” which does not even remotely link causality to their hypothesis.

Moreover, the active ingredients cited in the paper are not proposed for use in the District’s Integrated Vector Management Program (IVMP). See also responses to email Comment I-Fra7.

Response 42

This statement by the commenter is not substantiated or verified and, although an interesting observation, is not supported by the data provided in the article cited in Response 41 above or any evidence relevant to the PEIR or the District’s IVMP.

Response 43

The commenter suggests that her goal is to have healthy grandchildren. Comment noted.

Additional References

Brodman, R., W.D. Newman, K. Laurie, S. Osterfeld, and N. Lenzo. 2010. Interaction of an aquatic herbicide and predatory salamander density on wetland communities. Journal of Herpetology 44(1):69-82

National Park Service. 2016. Invasive Plant Management Plan for Yosemite National Park ESA.

National Agriculture Statistics Service (NASS). 2016. Honey Bee Surveys and Reports. Available online at https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Bee_and_Honey/#bee_honey.

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T-Petaluma

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MARIN/SONOMA MOSQUITO AND VECTOR CONTROL DISTRICT

Public Review and Hearing of
Draft Programmatic Environmental Impact Report (PEIR)
For the Marin/Sonoma Mosquito and
Vector Control District's
Integrated Vector Management Program

SCH#2012052066

PETALUMA COMMUNITY CENTER

320 N. MCDOWELL BLVD.

PETALUMA, CALIFORNIA

MONDAY, SEPTEMBER 21, 2015

Reported by:

Julie Link

CALIFORNIA REPORTING LLC
(415) 457-4417

T-Petaluma

APPEARANCES

Philip D. Smith, District Manager

Susan Hootkins, Senior Consultant

Public

None

T-Petaluma

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T-Petaluma

PETALUMA, CALIFORNIA

MONDAY, SEPTEMBER 21, 2015 6:38 P.M.

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MS. HOOTKINS: Okay. At this point, I'm going to open the public hearing. Julie will start to transcribe.

MALE VOICE: Maybe you can mention that they will need to come up so that we can (inaudible).

MS. HOOTKINS: Yes. If anyone wishes to speak, I'd like you to fill out a speaker card and you will be coming up here to address us all.

And be sure and speak into this microphone so that it is recorded by the court reporter.

At this point does anyone wish to speak tonight? All right.

I'll tell you what. I think what we'll do is we'll put the hearing part into suspension. We might still have someone come and want to speak, so we'll hang out for a little while.

So at this point I'm not going to close the public hearing, it is just going into suspension.

So thank you.

(Off the record 6:39 p.m. to 7:22 p.m.)

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MR. SMITH: Seeing no further commenters, it's 7:22 p.m. and we close the public hearing.

(Adjourned at 7:22 p.m.)

--o0o--

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REPORTER'S CERTIFICATE

I do hereby certify that the testimony in the foregoing hearing was taken at the time and place therein stated; that the testimony of said witnesses were reported by me, a certified electronic court reporter and a disinterested person, and was under my supervision thereafter transcribed into typewriting.

And I further certify that I am not of counsel or attorney for either or any of the parties to said hearing nor in any way interested in the outcome of the cause named in said caption.

IN WITNESS WHEREOF, I have hereunto set my hand this 28th day of September, 2015.

Juliana Link
CER-830

CALIFORNIA REPORTING LLC
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TRANSCRIBER'S CERTIFICATE

I do hereby certify that the testimony in the foregoing hearing was taken at the time and place therein stated; that the testimony of said witnesses were transcribed by me, a certified transcriber and a disinterested person, and was under my supervision thereafter transcribed into typewriting.

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IN WITNESS WHEREOF, I have hereunto set my hand this 28th day of September, 2015.

Terri Harper

Terri Harper
Certified Transcriber
AAERT No. CET**D-709

CALIFORNIA REPORTING LLC
(415) 457-4417

Hearing Transcript T-Petaluma

September 21, 2015

Petaluma, California

There were no oral comments or written comments handed in at the hearing. No responses are required.

6 Revisions to Draft PEIR

6.1 Introduction

This chapter presents minor revisions to text and appendices based on comments received or errors/errata discovered by the Draft PEIR preparers and/or District staff. None of these text changes or additions result in any changes to the conclusions and determinations of significant impact. In other words, no "less than significant" impacts were changed to "potentially significant" or "significant and unavoidable" impacts.

6.2 Text Revisions in Response to Draft PEIR Comments or District Identified Errors and Omissions/Clarifications

The sections below explain both content clarifications and typographical and transcriptional errors that were identified since the public release of the Integrated Vector Management Program, Programmatic EIR on August 13, 2015. Material to be added is underlined; material to be deleted is shown with ~~strikethrough font~~.

6.2.1 Summary

Under Section S.6 Summary of Environmental Impacts, the Summary Table S-2, Section 10. Air Quality, Mitigation Measures column (page S-15), the introduction to the measures is revised for clarity:

> "To mitigate Impact AQ-25, the District and its contractors ~~may~~ shall implement ~~any~~ one or more of the following measures as applicable to the specific application situation to reduce drift towards human populations/residences from the ground and aerial application of odorous treatment compounds:"

6.2.2 Chapter 1, Introduction

In Section 1.1.3.1.1, Cooperative Agreement between the California Department of Public Health and Local Vector Control Agencies, on page 1-7, the following typographical error is corrected.

> In 2015, CDFW determined that CDPH, and the districts operating under a valid Cooperative Agreement with CDPH to conduct surveillance, prevention, or control of vectors and vector-borne diseases, are not required to obtain a scientific collecti~~ons~~ng permit (SCP) under Fish and Game Codes Sections 1002, 4005(e), and 4011. A SCP is required for any scientific study conducted by or in collaboration with CDPH or local agencies, which is not routine surveillance and control activities and includes take of animals or plants. (CDFW 2015)

6.2.3 Chapter 2, Program Description

Section 2.3.2.1 (page 2-11) includes the following text (with typographical errors and omissions corrected).

> "The District performs these physical control activities in accordance with all appropriate environmental regulations (e.g., wetland fill and dredge permits, endangered species review, water quality review, streambed alteration permits, see Section 2.~~7~~8), and in a manner that generally maintains or improves habitat values for desirable species. Major physical control activities or projects (beyond the scope of the District's 5-year regional wetlands permits with the United States Army Corps of Engineers (USACE), San Francisco Bay Regional Water Quality Control Board (RWQCB), State Water Resources Control Board (SWRCB), and San Francisco Bay Conservation and Development

Commission (BCDC) are not addressed under this PEIR (because they are not known at this time). Minor physical control activities (covered by the regional wetlands permits) are addressed in this PEIR. They vary substantially from year to year, but typically consist of up to 10,000 linear feet of ditch maintenance. Under the regional permits, the District's work plans are reviewed annually by trustee and other responsible agencies prior to initiation of the planned work. USACE, USFWS, CDFW, and other responsible agencies can inspect documentation of proposed and completed work.

In Section 2.4 Education, the PEIR text has been modified on page 2-41 to clarify the applicable exemptions (shown below).

Public education is a key component of the District's IVMP that is used to encourage and assist reduction and prevention of vector habitats on private and public property. This component includes educational or training programs that involve no physical alteration in the area affected. While this component is a critical element of the District's Program, public education activities are categorically exempt from CEQA review (CEQA Guidelines Section 15322) based on a finding by the State Secretary of Resources that these activities do not have a significant effect on the environment. ~~Therefore, these educational activities will not be further reviewed in this document.~~ Under Article 19, Categorical Exemptions, maintenance of existing landscaping and minor alteration of existing public or private structures, facilities, mechanical equipment, or topographical features, involving negligible or no expansion of use is covered in Section 15301, Existing Facilities. A discussion of exempt and nonexempt educational activities is provided in the following paragraphs.

Section 2.8.1.3 on the NPDES Pesticide Permits should be replaced with the three descriptions provided in Section 9.1.2.2.8 on pages 9-13, 9-14, and 9-15:

2.8.1.3 Statewide ~~General~~ NPDES Pesticide Permits ~~for Algae and Aquatic Weed Control~~

~~This General Permit regulates the discharge of aquatic pesticides (algaecides and aquatic herbicides) used for algae and aquatic weed control to waters of the United States. These are algaecides and aquatic herbicides with registration labels that explicitly allow direct application to water bodies. This General Permit became effective on December 1, 2013.~~

~~Except for discharges on tribal lands that are regulated by a federal permit, this General Permit covers the point source discharge to waters of the United States of residues resulting from pesticide applications using products containing 2,4-D, acrolein, copper, diquat, endothall, fluridone, glyphosate, imazamox, imazapyr, penoxsulam, sodium carbonate peroxyhydrate, and triclopyr-based algaecides and aquatic herbicides, and adjuvants containing ingredients represented by the surrogate nonylphenol. This General Permit covers only discharges of algaecides, and aquatic herbicides that are currently registered for use in California, or that become registered for use and contain the above-listed active ingredients and ingredients represented by the surrogate of nonylphenol.~~

~~A Discharger under this General Permit includes any entity involved in the application of algaecides and aquatic herbicides that results in a discharge of algaecides and aquatic herbicides and their residues and degradation byproducts to waters of the United States, and meets either or both of the following two criteria:~~

- ~~The entity has control over the financing for or the decision to perform algaecide and aquatic herbicide applications that result in discharges, including the ability to modify those decisions; or~~
- ~~The entity has day-to-day control of algaecide and aquatic herbicide applications or performs activities that are necessary to ensure compliance with this General Permit. For example, the~~

~~entity is authorized to direct workers to carry out activities required by this General Permit or perform such activities themselves.~~

In response to a Sixth Circuit Court decision in 2009 that the application of pesticides at, near, or over waters of the US that results in discharges of pollutants requires coverage under a NPDES permit, the SWRCB adopted four Pesticide Permits. The first two are applicable to the Program. The Spray Applications Permit is also relevant to the regulatory setting when the District performs pesticide applications for the CDFA and/or USFS.

> Statewide NPDES Vector Control Permit. The Statewide NPDES Permit for Biological and Residual Pesticide Discharges to waters of the US from Vector Control Applications (SWRCB Water Quality Order No. 2011-0002-DWQ with amendments; NPDES No. CAG 990004; Vector Control Permit) covers the point source discharge of biological and residual pesticides resulting from direct and spray applications for vector control. The District completed application requirements, including preparation of a Pesticide Application Plan (PAP) and public notice requirements, and received permit approval on October 31, 2011. Permitted larvicide active ingredients include monomolecular films, methoprene, *Bacillus thuringiensis* subspecies *israelensis* or Bti, *Bacillus sphaericus* or Bs, temephos, petroleum distillates, and spinosad. Permitted adulticide active ingredients include malathion, naled, pyrethrin, deltamethrin, lambda-cyhalothrin, permethrin, resmethrin, sumithrin, prallethrin, the synergist PBO, etofenprox, and N-octyl bicycloheptene dicarboximide (MGK-264). The permit also includes language that allows adulticides and larvicides that are newly registered in California and that are based on active ingredients currently registered by CDPR to be used for vector control without having to further amend the permit. The permit contains a receiving water limitation for malathion and receiving water monitoring triggers for the other active ingredients. To obtain coverage under the permit, each discharger (typically a vector control district) must submit a Notice of Intent, application fee, and PAP, which is subject to approval by the SWRCB following a 30-day public comment period.

  The PAP serves as a comprehensive plan developed by the discharger that describes the project, the need for the project, what will be done to reduce water quality impacts, and how those impacts will be monitored. The PAP must include a description of application and target areas, evaluation of available BMPs, and description of BMPs to be implemented. The PAP must include a discussion of the factors influencing the decision to select pesticide applications for vector control, the pesticide products or types expected to be used, and any known degradation by-products. The PAP also includes the methodology used to determine how much pesticide is needed and how this amount was determined, the methods in which pesticides are to be applied, and any adjuvants or surfactants that will be used.

  Permittees must comply with the Vector Control Permit Monitoring and Reporting Program (MRP). Visual monitoring may be required during and after pesticide applications, when safe and feasible, to visually assess the area in and around where pesticides are applied for possible and observable adverse incidents. Monitoring of application rates is also required. Adverse incidents must be reported to the RWQCB within 24 hours of identification. Within 30 days a written report must be submitted, which includes a description of actions to be taken to prevent recurrence of adverse incidents. The District submits annual reports that include a description of the type of pesticide used, the quantity used, the location of where the pesticide is used, submittal of documentation such as the Pesticide Application Logs, and review of their PAP.

> Statewide NPDES Aquatic Weed Control Permit. The Statewide General NPDES Permit for Residual Aquatic Pesticide Discharges to Waters of the US from Algae and Aquatic Weed Control Applications (SWRCB Water Quality Order No. 2013-0002-DWQ with amendments;

NPDES No. CAG 990005; Aquatic Weed Control Permit) addresses the discharge of residues resulting from pesticide applications using products containing 2,4-D, acrolein, copper, diquat, endothall, fluridone, glyphosate, imazamox, imazapyr, penoxsulam, sodium carbonate peroxyhydrate, triclopyr-based algicides and aquatic herbicides, and adjuvants containing ingredients represented by nonylphenol. The permit contains receiving water limitations for 2,4-D, acrolein, copper, diquat, endothall, fluridone, glyphosate, nonylphenol, toxicity, and dissolved oxygen. The permit also includes receiving water monitoring triggers for imazapyr and triclopyr triethylamine. To obtain coverage under the permit, a discharger must submit a Notice of Intent, application fee, and a vicinity map to the appropriate RWQCB. Effluent limitations contained in the Aquatic Weed Control Permit require that the discharge of residual algicides and aquatic herbicides meet applicable water quality standards, require implementation of BMPs, and include requirements to develop and implement an Aquatic Pesticide Action Plan (APAP).

The APAP must describe appropriate BMPs, including compliance with all pesticide label instructions, and a monitoring plan that meets the requirements of the permit MRP. Monitoring requirements include background, event, and post-event sampling for visual, physical, and chemical constituents for each type of aquatic pesticide used for each type of site (flowing water and nonflowing water). Annual reports must summarize monitoring data and address the effectiveness of the APAP to reduce or prevent the discharge of pollutants associated with aquatic pesticide applications. Other specific requirements of the APAP include a description of the waterbody(ies) or waterbody systems being controlled and a description of what weed(s) are being controlled and why. The APAP also serves as a discussion of control tolerances (i.e., how much growth can occur before action is necessary) and of the factors influencing the decision to use aquatic pesticides in regards to those tolerances (pros and cons). The types of pesticides and adjuvants that are used and the methodology used to determine the amount of product to be applied are also detailed within an APAP. Finally, the APAP should have a description of application and treatment areas within the system and, if applicable, a list of gates or control structures and their inspection schedule to ensure they are not leaking.

> Statewide NPDES Spray Applications Permit. The Statewide General NPDES Permit for Biological and Residual Pesticide Discharges to Waters of the US from Spray Applications (SWRCB Water Quality Order No. 2011-0004-DWQ; NPDES No. CAG 990007; Spray Applications Permit) addresses spray applications of insecticides and herbicides by CDFA and USFS. Under the permit, CDFA is covered for applications of acetamiprid, aminopyralid, *Bacillus thuringiensis*, subspecies *kurstaki* (*Btk*), carbaryl, chlorsulfuron, clopyralid, cyfluthrin, dinotefuran, glyphosate, imazapyr, imidacloprid, malathion, naled, nuclear polyhedrosis virus (NPV), pheromone, pyrethrins, spinosad A and D, triclopyr butoxyethyl ester (BEE), and triclopyr triethylamine salt (TEA). USFS is covered for applications of biological control agents, which is a subset of the CDFA active ingredients.

The permit contains a receiving water limitation for malathion and receiving water monitoring triggers for many of the other active ingredients. To obtain coverage under the permit, the discharger must submit a Notice of Intent, application fee, and a project- or program-specific PAP to the SWRCB. The PAP must describe the application area, appropriate BMPs for each pesticide project, an evaluation of possible alternatives to pesticide use, and a monitoring plan. The PAP must also include an Off-Target Drift Management Plan. Monitoring requirements include background and event monitoring for visual, physical, and chemical parameters at frequencies similar to the Vector Control Permit. Annual reports must summarize sampling results and recommend improvements to the monitoring program, BMPs, and PAP.

Section 2.8.1.7 is added to provide a description of the District's most recent Lake and Streambed Alteration Agreement with CDFW.

Section 2.8.1.7 Lake and Streambed Alteration Agreement

The District had a LSAA with CDFW (CDFW 2010) that covered work in habitats under CDFW jurisdiction under Section 1600 of the Fish and Game Code at 97 sites in Sonoma and Marin Counties. The 2010 LSAA listed 59 sites in Sonoma County and 28 sites in Marin County, mostly riparian zones/creeks, seasonal low areas, drainage ditches, wetlands and ponds. This LSAA was amended in 2012 and 2013 to add an additional 10 sites. These sites represent areas of active mosquito surveillance and limited vegetation removal. The LSAA covers maintenance of access into riparian zones, and beds and basins of creeks, seasonal depressions and low areas, seasonal wetlands, ponds, and storm water drainage ditches to perform mosquito surveillance, mosquito-borne disease surveillance, and mosquito control at all 97 sites. Covered project activities include:

> Minor trimming of vegetation (generally 3-inches diameter or less)

> Trimming of overhanging limbs and brush

> Removal of small sections of downed trees or limbs within channels

> Mowing

The permit contains specific avoidance and minimization measures and requires written notification of maintenance projects completed annually with reports due by June 30. It also has requirements that inform the BMPs. Permit requirements state that activities are to be conducted from October 1 through April 30, and the District attempts to complete the work prior to the onset of seasonal rainfall. (CDFW 2010[1]). The LSAA expired December 31, 2014, and will be renewed.

In Section 2.9, Best Management Practices, the following changes are made to page 2-54.

Subsequent environmental impact assessments in this PEIR reflect the continued use of these measures, which are organized under the following categories and listed in Table 2-6:

> General BMPs

> Tidal Marsh-Specific BMPs

> Salt Marsh Harvest Mouse (SMHM)

> Ridgway's Rail (RIRA)

> Soft Bird's Beak (SBB)

> Vegetation Management

> Maintenance/Construction and Repair of Channels, Tide Gates and Water Structures in Waters of the U.S and State.

> Applications of Pesticides, Surfactants, and/or Herbicides

> Hazardous Materials and Spill Management

> Worker Illness and Injury Prevention Program and Emergency Response.

[1] California Department of Fish and Wildlife (CDFW). 2010. Final Lake or Streambed Alteration Agreement, No. 1600-2010-0252-R3. Public Health/Mosquito Control Access Maintenance. Amended March 5, 2012 and October 14, 2013 by Erik Hawk, MSMVCD.

In Table 2-6, the following changes have been incorporated to reflect responses to comments.

The following modification to BMP A1 is made (page 2-57):

> District staff has had long standing and continues to have cooperative, collaborative relationships with federal, state, and local agencies and with special interest groups and land managers/owners. The District regularly communicates with agencies, organizations, and land managers/owners regarding the District's operations and/or the necessity and opportunity for increased access for surveillance, source reduction, habitat enhancement, and the presence of special status species and wildlife. The District often participates in and contributes to interagency and special interest group projects. The District will continue to foster these relationships, communication, and collaboration.

BMP A10 (page 2-58) has been revised to include invasive animal species such as New Zealand mud snails and amphibian pathogens such as the chytrid fungus.

> Properly train all staff, contractors, and volunteer help to prevent spreading weeds and ~~pests~~invasive animal species (e.g., New Zealand mud snails) or pathogens (e.g., the fungus that causes chytridiomycosis in amphibians) to other sites. The District headquarters contains wash rack facilities (including high-pressure washers) to regularly (in many cases daily) and thoroughly clean equipment to prevent the spread of weeds. In addition, MSMVCD will provide equipment, such as an air compressor, to clean equipment in the field when there is a concern about the transfer of weed seeds. Decontamination methods to clean equipment and personnel clothes, such as boots, of invasive species and pathogens will be included in worker training and be implemented when working in wetlands in different watersheds.

BMP F6 (page 2-63) has been revised below as requested by CDFW.

> Vegetation management work will be generally confined to October 1 to April 30 to minimize potential impacts to sensitive species, especially breeding birds. ~~When~~ If work is expected to occur between February 1 and ~~April 30~~ August 31 (nesting season for migratory birds), additional consultations will occur with appropriate resource agencies to help identify locations of active nests of raptors or migratory birds as well as any additional protection measures that will need to be implemented prior to commencement of work.

BMP F9 (page 2-64) has been revised as indicated below:

> Within suitable habitat for California Freshwater Shrimp (*Syncaris pacifica*), no in-channel vegetation will be removed, trimmed, or otherwise disturbed. District staff will work with resource agencies to determine locations of suitable habitat for California Freshwater Shrimp and receive written authorization from USFWS to proceed prior to commencement of vegetation management activities.

BMP F 10 (page 2-64) has been revised as indicated below:

> If suitable habitat ~~necessary~~for special-status species is found, including vernal pools, and if nonchemical physical and vegetation management control methods have the potential for affecting special-status species, then the District will coordinate with the CDFW, USFWS, and/or NMFS, as appropriate, before conducting control activities within this boundary or cancel activities in this area. If the District determines no suitable habitat is present, control activities may occur without further agency consultations.

Category G of the BMPs (page 2-64) has been modified to:

> G. Maintenance / Construction and Repair of Channels, Tide Gates, and Water Structures in Waters of the U.S. and State

BMP G9 (page 2-66) has been modified as indicated below:

> Discharges of dredged or fill material into tidal waters will be minimized or avoided to the maximum extent possible at the project site and will be consistent with all permit requirements for such activity. No discharge of unsuitable material (e.g., trash) will be made into waters of the United States or State of California, and material that is discharged will be free of toxic pollutants in toxic amounts (see section 307 of the Clean Water Act). Measures will be taken to avoid disruption of the natural drainage patterns in wetland areas.

BMP H10 (page 2-68) is modified as indicated below:

> Special-Status Aquatic Wildlife Species:
>
> > Suitable habitat will be determined using methods such as recent aerial photographs, results of previous survey data from scientific literature or reports, site-specific survey data, and databases such as CNDDB.
>
> > A CNDDB search was conducted in 2012 and the results incorporated into Appendix A for this PEIR. An update was completed in November 2014 and the results incorporated into Section 4.1.2 of this PEIR. District staff communicates with state, federal, and county agencies regarding sites that have potential to support special status species. Many sites where the District performs surveillance and control work have been visited by staff for many years and staff is highly knowledgeable about the sites and habitat present. If new sites or site features are discovered that have potential to be habitat for special status species, the appropriate agency and/or landowner is contacted and communication initiated.
>
> > Use only pesticides, herbicides, and adjuvants approved for aquatic areas or manual treatments within a predetermined distance from aquatic features (e.g., within 15 feet of aquatic features). Aquatic features are defined as any natural or man-made lake, pond, river, creek, drainage way, ditch, spring, saturated soils, or similar feature that holds water at the time of treatment or typically becomes inundated during winter rains.
>
> > If suitable habitat for special status species is found, including vernal pools, and if aquatic-approved pesticide, herbicide, and adjuvant treatment methods have the potential for affecting the potential species, then the District will coordinate with the CDFW, USFWS, and/or National Marine Fisheries Service (NMFS) before conducting treatment activities within this boundary or cancel activities in this area. If the District determines no suitable habitat is present, treatment activities may occur without further agency consultation.

These BMPs are repeated in many of the resource chapters and are hereby modified as well.

6.2.4 Chapter 4, Biological Resources - Aquatic

The corrections to Table 4-4 on pages 4-36 and 4-37 are:

> California black rail: remove X under FW Marsh/Seeps
>
> ~~California clapper~~Ridgway's rail

The text in Section 4.1.3.1.6 Stipulated Injunction and Order, Protection of California Red-Legged Frog from Pesticides, on page 4-42, has been corrected as indicated below.

> Of the 66 pesticides listed in the injunction, the District may employ esfenvalerate~~,~~ and methoprene, ~~and permethrin~~ for vector control. Esfenvalerate may be used for yellow-jacket and wasp control in response to public complaints. Methoprene is used for larval mosquito control ~~and permethrin is may be used for adult mosquito control~~. However, vector control programs are exempt. Specifically, for applications of a pesticide for purposes of public health vector control under a program administered by a public entity, the injunction does not apply. The District may

use the following herbicides listed in the injunction: glyphosate, imazapyr, and triclopyr. Where used for vegetation management for control of mosquito-breeding habitat, the injunction would not apply.

Section 4.1.4.5 Bay Delta Conservation Plan, has been removed from pages 4-48 and 4-49.

~~The BDCP is an HCP being developed as part of California's overall water management portfolio. It is being developed as a 50-year habitat conservation plan with the goals of restoring the Sacramento-San Joaquin River Delta (Delta) ecosystem and securing California water supplies. The plan area encompasses the legal Delta and surrounding areas (Solano, Yolo, Contra Costa, San Joaquin and Sacramento counties). It does not border Marin or Sonoma Counties, but does encompass parts of adjoining Solano County. The activities covered under the BDCP include improvements to water infrastructure facilities in and around the Delta and the protection of approximately 150,000 acres of habitat to address the Delta's environmental challenges. The BDCP includes 22 conservation measures aimed at improving water operations, protecting water supplies and water quality, and restoring the Delta ecosystem within a stable regulatory framework (BDCP 2014).~~

~~The BDCP seeks coverage for 56 species and identifies conservation measures designed to contribute to their protection and recovery. The plan includes 67 goals and 165 objectives that form the basis of the conservation strategy, which includes landscape scale, natural community and biological and species specific goals and objectives. The BDCP also includes 37 AMMs that are incorporated into covered activities to minimize the effects of these actions on various resources. Many of these AMMs focus on minimizing the general environmental effects of construction activities and many others are species specific AMMs.~~

~~AMM 33 Mosquito Management calls for management and control of mosquitoes during construction of project facilities. The HCP Implementation Office will accomplish this through consultation with appropriate mosquito and vector control districts and will carry out mosquito control activities as necessary and applicable. The types of mosquito control activities that may be carried out under this AMM include surveillance, biological controls, physical controls, vegetation management, and use of larvicides and adulticides, as necessary.~~

In Section 4.2.2.6 of the Draft PEIR, the following statement on page 4-75 on predator populations is modified as indicated for greater clarity:

"Mosquitoes are part of the food web and their loss may reduce the food base for some predators. Although mosquitoes serve a role as one of many types of prey items for some fish, avian insectivores, bats, and small reptiles and amphibians, the reduction of mosquito abundance over a small area will not affect the predator populations overall because these species generally have large foraging ranges and can find~~, as~~ other prey sources within the range of their habitat use~~ are available~~." (Williams et al, 1994)[2]

6.2.5 Chapter 5, Biological Resources - Terrestrial

Section 5.1.4.5 Bay Delta Conservation Plan, has been removed from pages 5-28 and 5-29.

~~The BDCP is an HCP being developed as part of California's overall water management portfolio. It is being developed as a 50-year habitat conservation plan with the goals of restoring the Sacramento-San Joaquin River Delta (Delta) ecosystem and securing California water supplies. The plan area encompasses the legal Delta and surrounding areas (Solano, Yolo, Contra Costa, San Joaquin and Sacramento counties). It does not border Marin or Sonoma Counties, but does encompass parts of adjoining Solano County. The activities covered under the BDCP include~~

[2] Williams. B. et al., eds. 1994. Assessing Pesticide Impacts on Birds. Final Report of the Avian Effects Dialogue Group, 1988-1993. RESOLVE, Center for Environmental Dispute Resolution.

~~improvements to water infrastructure facilities in and around the Delta and the protection of approximately 150,000 acres of habitat to address the Delta's environmental challenges. The BDCP includes 22 conservation measures aimed at improving water operations, protecting water supplies and water quality, and restoring the Delta ecosystem within a stable regulatory framework (BDCP 2014).~~

~~The BDCP seeks coverage for 56 species and identifies conservation measures designed to contribute to their protection and recovery. The plan includes 67 goals and 165 objectives that form the basis of the conservation strategy, which includes landscape scale, natural community and biological and species specific goals and objectives. The BDCP also includes 37 AMMs that are incorporated into covered activities to minimize the effects of these actions on various resources. Many of these AMMs focus on minimizing the general environmental effects of construction activities and many others are species specific AMMs.~~

~~AMM 33 Mosquito Management calls for management and control of mosquitoes during construction of project facilities. The HCP Implementation Office will accomplish this through consultation with appropriate mosquito and vector control districts and will carry out mosquito control activities as necessary and applicable. The types of mosquito control activities that may be carried out under this AMM include surveillance, biological controls, physical controls, vegetation management, and use of larvicides and adulticides, as necessary.~~

6.2.6 Chapter 10, Air Quality

The following text change from Section 10.2.7 Chemical Control Alternative on page 10-32 will be carried into Section 10.2.11 (page 10-41) and Summary Table S-2 (page S-15).

"To mitigate Impact AQ-25, the District and its contractors ~~may~~ shall implement ~~any~~ one or more of the following measures as applicable to the specific application situation to reduce drift towards human populations/residences from the ground and aerial application of odorous treatment compounds:"

6.2.7 Chapter 15, Alternatives

Under Section 15.3 No Program, on pages 15-2 and 15-3, the following material is added after the third bullet at the bottom of page 15-2:

…The No Project/No Program condition assumes that the current activities would cease and result in a "do nothing" alternative going forward. Key assumptions for the future No Program Alternative are:

> Current regulatory controls would continue and expand as needed; however, the District would not engage in implementing any of these regulations concerning public health and management of vectors carrying potential diseases. For all practical purposes, the District's office would close. Public education and other outreach activities would cease along with the control activities.

> Private landowners would manage mosquito and/.or vector problems on private land without any state or federal oversight with pesticides approved for use. Households would use pesticides commonly available from retail outlets where permethrin and pyrethroids are common ingredients.

> In the absence of the District's IVMP, the responsibility for vector management could fall on CDPH (or some other agency), who would not provide mosquito and vector control support or "oversight" to local jurisdictions (from Sacramento) given lack of personnel, equipment, or funding. Management at the state level would likely be only reactive rather than proactive.

A study of residential pesticide use in California, including the San Francisco Bay Area, was conducted to understand consumer behavior and sources of pesticides in urban waterways (Flint 2003[3]). The UC Statewide Integrated Pest Management (IPM) Program sponsored a telephone survey and a shelf survey of pesticide products to collect information about outdoor pesticide use, pest control practices, and attitudes of residents in 2002-2003. It includes the following findings (from the Chapter 1 Summary) that are most relevant to the analysis herein:

> Insects were considered by far the greatest outdoor pest problem in all northern California areas. Ants were the most common pest treated by residents themselves or by professional applicators hired by the homeowner.

> More respondents in the Bay Area (40.6 percent) reported no outdoor use of pesticides than in any other area.

> The largest share of the respondents who had applied pesticides in the past 6 months stated that they normally applied pesticides between 1 and 3 times a year. About one third applied pesticides more than 3 times a year, and 3.4 percent of the Bay Area respondents applied pesticides more than 12 times a year.

> Only a minority of residents hire pest control professionals to manage outdoor problems.

- Almost half of respondents in the three northern California watersheds disposed of pesticides improperly. Many of these threw pesticide containers containing pesticides into the trash, but 5-15 percent in each area admitted to pouring mixed pesticides into inside or outside drains or the street gutter.
- Substantial numbers (44-62 percent in all areas) “estimate” rather than follow label directions precisely when measuring and mixing pesticides. About half of the products used by residents were ready-to-use products requiring no mixing or dilution.
- Large home supply stores accounted for 42 to 52 percent of all pesticide sales to residential users in northern California.
- The store shelf survey found that certain active ingredients were very dominant in the market, including 78 different products containing the insecticide permethrin. Another pyrethroid used primarily for indoor pests, tralomethrin, was found in 32 products. Other common active ingredients were the herbicide dicamba (28 products), the insecticide pyrethrin (26 products), and the herbicide glyphosate (25 products).
- Retail shelves contained unregistered pesticides. Pesticides that are no longer registered for use in California were found on shelves of many of the stores surveyed.

The District would perform no surveillance, physical control, vegetation management, biological control, chemical control or other nonchemical control activities within its Service Area or in adjacent jurisdictions. “Do nothing” means the District would cease to exist and not provide the services funded by local property taxes. It is assumed that CDPH would not be able to provide even limited vector management services at the local level. As a result of the No Program assumptions, the vectors of human and animal disease and discomfort would be more numerous than under existing conditions, and proliferate such that outbreaks of disease and illness would occur more frequently.

[3] Flint, M.L. 2003. Residential Pesticide Use in California: A Report of Surveys taken in the Sacramento (Arcade Creek), Stockton (Five-Mile Slough), and San Francisco Bay Areas with Comparisons to the San Diego Creek Watershed of Orange County, California. Prepared for the CDPH. Director, IPM Education and Publications and Extension Entomologist, University of California Statewide IPM Program, University of California Davis. March 15.

6.2.8 Chapter 17. References

The following references were updated for new hyperlinks, and the previous hyperlinks are not shown. Also, additional references cited in this chapter are included.

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