

# **SUTTER-YUBA MOSQUITO & VECTOR CONTROL DISTRICT'S BEST MANAGEMENT PRACTICES TO REDUCE MOSQUITOES**



## **BEST MANAGEMENT PRACTICES TO REDUCE MOSQUITOES**

The Best Management Practices (BMPs) contained in this manual are assembled from a number of sources, including scientific literature, state and inter-agency documents, and experienced vector control professionals. The intended use of this document is to provide general guidance, not site-specific requirements. BMPs that are most applicable to a specific mosquito-breeding source may be selected from the list and incorporated into a specific BMP Implementation Plan in consultation with the District personnel.

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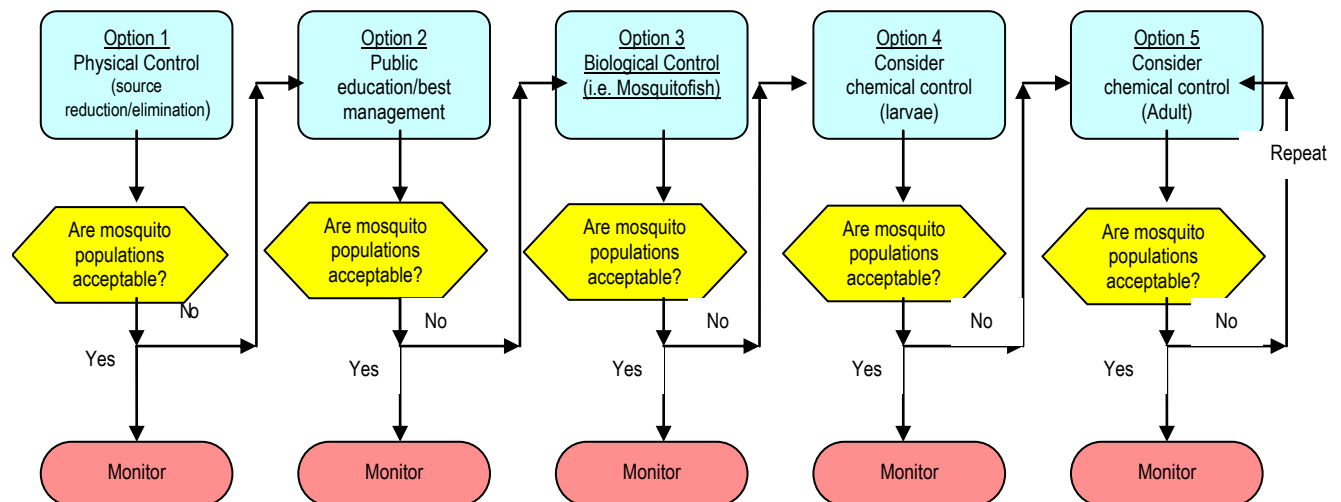
# BMP IMPLEMENTATION POLICIES

## INTRODUCTION

The Sutter-Yuba Mosquito & Vector Control District (District) is aware that adjusting land management practices can reduce mosquito populations, thereby lowering mosquito control costs, reducing the amount of pesticide used in mosquito control applications, helping to protect the public's health, and contributing to the District's Integrated Mosquito Management (IMM) approach to mosquito and vector control.

IMM is an effective and environmentally sensitive approach to mosquito management that relies on a combination of common-sense practices. The District's IMM program uses current, comprehensive information on the life cycles of mosquitoes and their interaction with the environment. This information is used to manage mosquito nuisance and public health threats by the most economical means and with the least possible hazard to people, property, and the environment. The District's IMM includes vector surveillance, source reduction, manipulation and/or elimination, best management practices, public education, biological control, chemical control, and monitoring.

### Integrated Mosquito Management (IMM) Program



There are four different types of mosquito control methods practiced by the District. The first is source reduction, manipulation, and/or elimination, which is a physical control method. Physical control is an environmental manipulation that results in the reduction or elimination of mosquito development sites. Biological mosquito control uses biological agents to reduce larval mosquito populations. The third control method is the use of federal- and state-registered pesticides to control mosquito populations. Two types of pesticides are utilized: adulticides, which kill adult mosquitoes, and larvicides, which are designed to kill immature aquatic-stage mosquitoes (larvae) or inhibit development to adult emergence. Cultural control is the fourth method utilized by the District. Cultural control is designed to change the behavior of the county's residents through public education and outreach so that their actions prevent mosquitoes. Each



method of control is designed to eliminate or minimize mosquito-breeding sites, reduce mosquito populations, and reduce transmission of vector-borne disease.

The District is continually striving to enhance its efforts to control mosquitoes effectively by physical, biological, and cultural means, lessening dependency on chemical control. With the adoption of these policies and procedures, this goal can be achieved. This manual includes the District's guidelines for land management practices that provide landowners and land managers techniques to address most mosquito-breeding problems that may be identified by the District.

The BMPs in this manual can reduce mosquito populations by several methods, including: reducing and/or eliminating standing water that serves as mosquito-breeding sources, increasing the efficacy of biological controls such as mosquitofish, increasing the efficacy of chemical controls, and improving access for mosquito control operations. Not all BMPs included in this manual will apply equally to all mosquito-breeding sources, but all BMPs are to be a starting point in the cooperative development of site-specific BMP implementation plans that will address the identified mosquito-breeding source(s).

The District recommends that those responsible for creating large mosquito populations by possessing a significant mosquito-breeding source on the identified property develop and implement a cooperative BMP plan with the District to avoid the need for formal enforcement actions authorized under the California Health and Safety Code. Under the California Health and Safety Code, section 2061, mosquito and vector control districts may legally abate a public health 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." Abatement can result in civil penalties of up to \$1,000.00 per day for each day of such violation and the recovery of costs for District activities to control the mosquitoes from a source. This includes sources outside the District boundaries that produce mosquitoes that then fly into the District.

Some circumstances require the District to utilize the California Health and Safety Code to ensure the public's safety and to carry out its responsibilities, but due to past experiences, the District believes that a cooperative approach leads to a more effective and long-lasting relationship, which, in turn, leads to the overall reduction of mosquitoes and mosquito-breeding sources.

BMP implementation policies in this manual are designed to address significant mosquito-breeding sites including, but not limited to: residential properties, commercial properties, industrial properties, public properties, cemeteries, wastewater facilities, storm water facilities, and agricultural production such as rice, orchards, row crops, pastures, ditches, managed wetlands, and duck clubs. Due to management practices that promote favorable habitat for mosquito production, many of the above listed properties and/or facilities produce significant populations of mosquitoes, which pose a public health nuisance and/or public health risk.

The policies in this manual are designed to address the most significant mosquito-breeding problems throughout the District. Mosquito-breeding sources defined as Significant Mosquito-Breeding Sources will be addressed according to the following policies and procedures. Mosquito-breeding sources that do not meet the criteria as a Significant Mosquito-Breeding Source will not be held accountable to the policies and procedures in this manual; however, use of this manual provide an opportunity to the landowner/land manager to take a proactive approach to mosquito problems and to avoid a property's becoming a significant mosquito-breeding source.

If the adoption and implementation of a BMP creates a significant economic hardship or causes technical difficulties, the District may elect to offer assistance in the form of equipment, labor, technical advice and/or other resources. Assistance will be considered and offered on a case-by-case basis and is not to be considered a guarantee.

## **SIGNIFICANT MOSQUITO-BREEDING SOURCES**

The following criteria will identify and define a Significant Mosquito-Breeding Source:

- Mosquito production exceeds District-adopted treatment thresholds;
- Mosquito production exceeds that of a similar source in a similar land use situation;
- Increased control costs are incurred by the District due to the management practices;
- Mosquito production is in close proximity to a populated area;

As defined by the California Health and Safety Code, a Significant Mosquito-Breeding Source would be considered a public nuisance if left untreated and may be subject to civil penalties of up to \$1,000.00 a day.

Adult and larval mosquito surveillance data will be gathered before and after the implementation of the BMPs Plan to measure the effectiveness of the program. If current sampling methods and existing surveillance data are not sufficient to determine the effectiveness of the particular BMP, a site-specific monitoring plan will be created to evaluate the Significant Mosquito-Breeding Source's implemented BMP.

When evaluating a Significant Mosquito-Breeding Source as defined above, the District will evaluate other factors such as the current level of vector-borne disease, mosquito species being produced, and the efficacy of available control options. Identified Significant Mosquito-Breeding Sources that are in close proximity to populated areas and/or have the highest potential to reduce mosquito production will be selected to adopt a BMP implementation plan compliant with this manual.

Many land management practices can contribute to increased mosquito production. Some of the management practices are, but are not limited to: lack of emergent vegetation control, lack of trash and debris removal, lack of proper maintenance to ensure facility or structural operation as design indicates, poor water management, poor condition of water conveyance or drainage structures, lack of adequate refuge for biological control populations, practices that deny or obstruct District access to the source, and the lack of notification of land management practices that would affect mosquito production or mosquito control operations.



## **BMP IMPLEMENTATION PLAN**

If a mosquito-breeding source is located and meets the criteria as a Significant Mosquito-Breeding Source, the District will develop and present a draft BMP Implementation Plan to the responsible landowner and/or manager, proposing the course(s) of action(s) based on one or more BMPs that, if implemented, will reduce or eliminate the mosquito-breeding source. If appropriate, the District will consult with state and federal biologists and/or other professionals to determine if the BMP being proposed is adequate and environmentally sound.

The draft BMP Implementation Plan will contain, but is not limited to, the following:

- Identification of a Significant Mosquito-Breeding Source
- Justification for the proposed and requested actions
- Clear and precise description of the proposed BMP(s)
- Timing of implementation and specific guidance of proposed BMP(s)
- District resource(s) available to assist with BMP implementation
- Assessment and surveillance method(s)

To achieve a mutually agreeable BMP Plan, the property owner/land manager will have the opportunity to review and comment on the proposed draft plan. Reasonable adjustments can and may be negotiated between the responsible property owner/land manager and the District during the review process. A reasonable time limit will be allowed during the negotiating process, at which time the District will finalize any and all unresolved issues. The time limit itself is subject to an extension if all parties mutually agree and reasonable cause is provided. If the responsible party is unwilling to accept the terms of the cooperative process upon conclusion of the review period, the District may be forced to pursue formal abatement proceedings.

## **REIMBURSEMENT FOR CONTROL COSTS**

The District is authorized by the California Health and Safety Code to recover treatment costs for mosquito control operations. Since most mosquito-treated properties in the District pay for a “base” level of mosquito control through property taxes, the District would consider charging for treatment costs that are above and beyond the normal level of treatment for mosquito control on mosquito-breeding sources with similar land use. Since the primary goal for the creation and use of this BMP manual is to lead to the reduction of pesticide use, the District would only consider accepting charges for additional treatment in lieu of BMPs on a case-by-case basis for a limited period of time. As new BMPs are developed and efficacy of existing BMPs are researched further, the expectation would be that the charge for treatment portions of the BMP Plans would be replaced by non-pesticide-based long-term mosquito management plans.

## **PROCESS OF APPEALS**

The responsible landowner/property manager may submit comments in writing to the Sutter-Yuba Mosquito & Vector Control District Board of Trustees before the implementation deadline of the Draft BMP Plan. Upon review, the Board of Trustees will issue a determination, which may include no change in the content of the draft BMP Plan, an extension of the implementation deadline, a waiver of reimbursement fees, or other appropriate action. If the responsible landowner/property manager is a state agency, appeals may be made to the California Department of Public Health pursuant to the California Health and Safety Code.

## PROCESS TO IMPLEMENT BMP PLAN

Below is a chronological list of progression that will lead to the creation of a BMP Plan for identified properties that meet the criteria for a Significant Mosquito-Breeding Source.

1. **Identification of a Significant Mosquito-Breeding Source**-The District will identify a significant Mosquito-Breeding Source based on the following criteria:
  - Mosquito production exceeds District treatment thresholds.
  - Mosquito production exceeds that of a similar source in a similar land use situation.
  - Increased control costs are incurred by the District due to the management practices.
  - Mosquito production is in close proximity to a populated area.
  - Mosquito production is on land where land management practices could be modified to reduce high populations of mosquitoes and future mosquito production.
2. **Contact responsible landowner** – The District will contact the responsible landowner of properties in Sutter and Yuba Counties that have been identified as Significant Mosquito-Breeding Source that, if untreated, would become a public nuisance (California Health and Safety Code section 2061) or a threat to public health. A draft BMP Plan will be provided to the responsible landowner that will include an explanation of why the site was identified as a Significant Mosquito-Breeding Source, including mosquito surveillance data and the management practices necessary to reduce mosquito production.
3. **Negotiate draft BMP Plan** – District staff will work with the responsible landowner to achieve a mutually agreeable course of action to address the Significant Mosquito-Breeding Source. During this stage in the process, specific BMPs, implementation timelines, maintenance requirements, and monitoring plans will be addressed and negotiated. A defined negotiation timeline will be designated at the start of this process.
4. **Acquire additional resources** – Resources may be made available to assist the responsible landowner to comply with the BMP requirements. If District resources are utilized, maintenance requirements will be specified in the cooperative agreement. This agreement will contain the name of the landowner utilizing the resource, location of the property, description of work being performed, the cost of work, if any, to be paid by the responsible landowner, and requirements for maintenance to be performed by landowner.
5. **Coordination with other regulatory agencies** – Other local, state, federal, and conservation agencies may be brought into the negotiating process to avoid any potential regulatory conflicts with the draft BMP Plan.

Vegetation management practices may adversely affect threatened and endangered species if occupied habitat is disturbed. Landowners are prohibited from “taking” endangered species under the U.S. and California Endangered Species Act. 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.

Listed wildlife includes Giant Garter Snake, Western Spadefoot Toad, Black Rail, Yellow Warbler, Western Yellow-billed Cuckoo, Tricolored Blackbird, etc. Listed plants include Woody Rose-mallow, Colusa Layla, Brownish Beaked-rush, etc. A complete list of these wildlife and plants can be found in appendix “A”. District staff is available to help landowners make an assessment of their property for the presence of occupied habitat of these species. Contact information for local offices of the U.S. Fish and Wildlife Service and California Department of Fish and Game can be found in appendix “B”.

Dredge or fill activities resulting from implementation of certain BMPs occurring in wetlands or Waters of the United States could result in habitat degradation associated with water quality impacts and/or the need for permits from the U.S. Army Corps of Engineers.

Waters of the U.S. includes essentially all surface waters such as all navigable waters and their tributaries, all interstate waters and their tributaries, all wetlands adjacent to these waters, and all impoundments of these waters.

Wetlands are those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and 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. Other examples include seasonal wetlands as well as vernal pools.

Section 404 of the Clean Water Act requires Corps’ authorization prior to discharging dredge or fill material into the waters of the U.S. The goal of this Act is to restore and maintain the chemical, physical, and biological integrity of the Nations waters. Any person or agency planning to work on waters of the U.S., or dump or place dredged or fill materials into waters of the U.S., must first obtain a permit from the Corps of Engineers. Contact information for the local offices of the Corps’ and the California Environmental Protection Agency can be found in appendix “B”.

6. **Cooperative agreement** – The District will generate a cooperative agreement to formalize the relationship between the responsible landowner and the District, specifying the terms agreed upon in the BMP Plan. The cooperative agreement will also state the consequences of noncompliance with the BMP Plan under the California Health and Safety Code.
7. **Implementation of BMP Plan and monitoring** – To ensure compliance and continued maintenance, the District will continually monitor the property after successful completion and implementation of the BMP. If reasonable mosquito

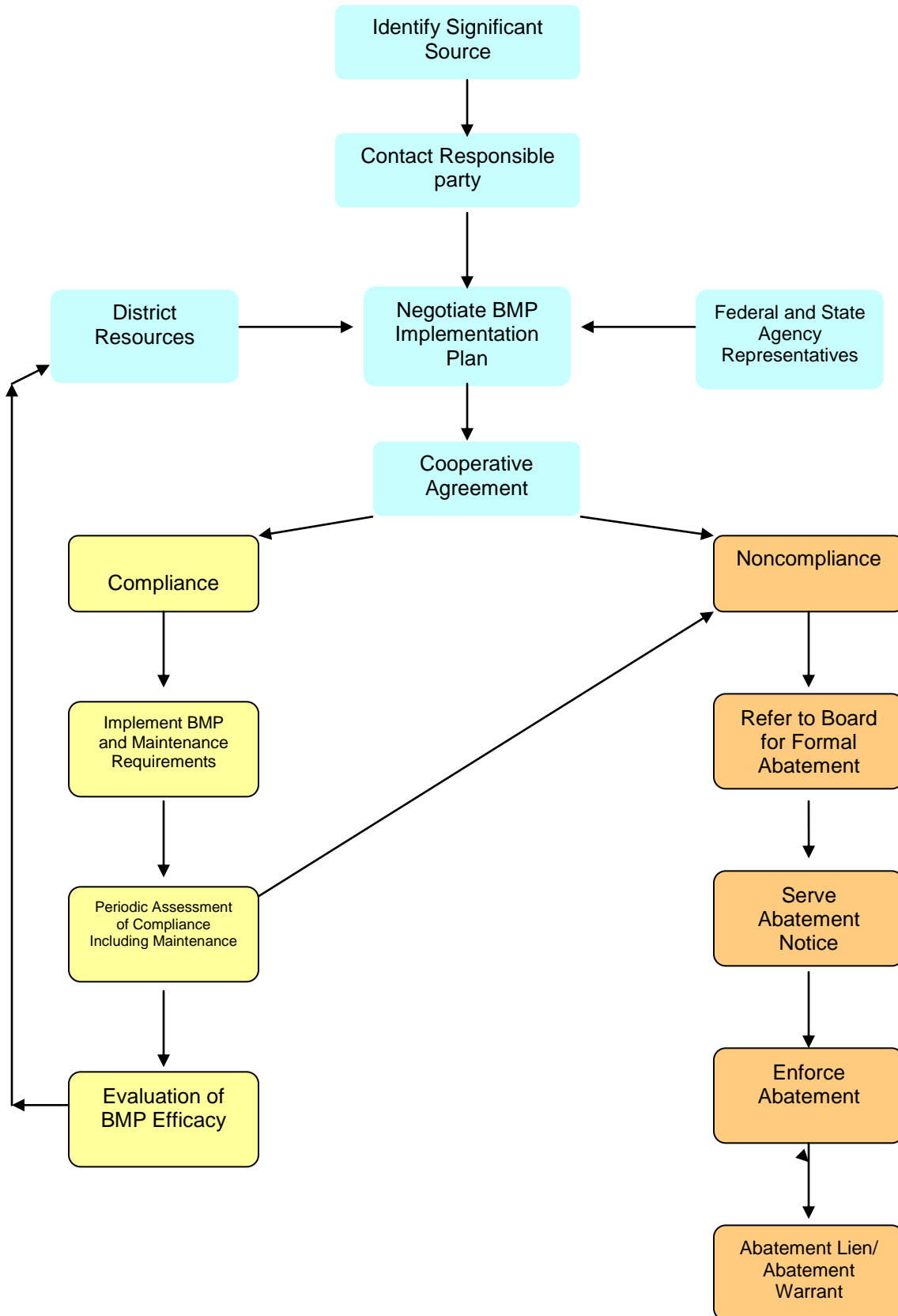
control is not achieved through the initial BMP Plan, the District reserves the right to renegotiate the BMP Plan at any time mosquito production is not reduced. If this happens, the process would return to step #2 (above). No additional charges or penalties will be assessed to the responsible landowner if the party is still compliant with the terms of the cooperative agreement.

8. **Evaluation of BMP efficacy to reduce mosquitoes** – The District will continually evaluate each BMP Plan to assess the efficacy and ensure that the BMPs are meeting the needs of the responsible landowner and the District. Based on the evaluation, either party may initiate a review of the BMP plan pursuant to the terms of the cooperative agreement. A mosquito management plan aimed at reducing mosquito populations requires regular assessments and adaptive management to address changing conditions and/or unforeseen effects.
9. **Formal abatement process** – If the responsible landowner of property that has been identified as a Significant Mosquito-Breeding Source does not take corrective action or does not provide reasonable explanation for the continued lack of compliance with the cooperative agreement, the case may be brought to the Sutter-Yuba Mosquito & Vector Control District Board of Trustees to begin the formal abatement process as defined in the California Health and Safety Code, section 2061.
10. **Serve abatement notice** – Under direction of the District Board of Trustees, the responsible landowner will be served an abatement notice directing the landowner to comply with the cooperative agreement within the specified timeframe. Noncompliant landowners can be fined civil penalties of up to \$1,000.00 per day for each day while in non-compliance and the recovery costs for District activities to control mosquitoes from a source, pursuant to the California Health and Safety Code, sections 2061 and 2063.
11. **Inform responsible landowner** - Before complying with the requirements of the notice, the owner may appear at a hearing of the District Board of Trustees at a time and place specified in the notice. The District Board of Trustees shall accept written and oral testimony from the landowner and other persons. At the close of the hearing, the District Board of Trustees shall find, based on substantial evidence in the record, whether a public nuisance exists on the property.
12. **Enforcement of abatement** – Under direction of the District Board of Trustees, civil penalties and treatment costs not paid within 60 days will be collected “at the same time and in the same manner as ordinary county taxes and shall be subject to the same procedure and sale in case of delinquency as are provided for ordinary county taxes.” California Health and Safety Code, section 2065(b).
13. **Additional abatement actions** – Under direction of the District Board of Trustees and/or District Manager, other measures such as an abatement warrant

or abatement lien may be imposed pursuant to the California Health and Safety Code.

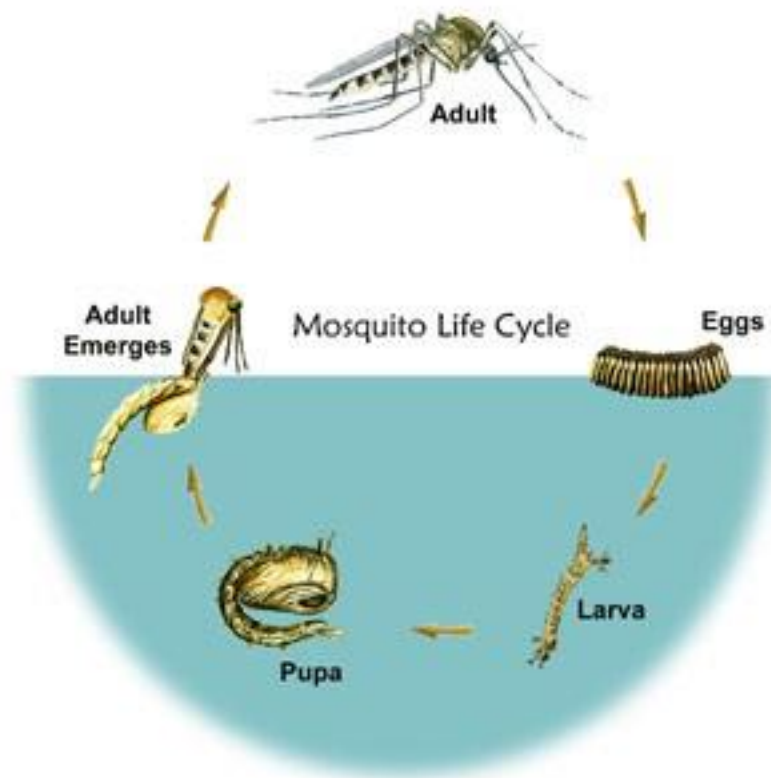


## THE BMP PROCESS FLOWCHART



## MOSQUITO BIOLOGY AND ASSOCIATED BREEDING HABITATS

There are over 3,000 mosquito species in the world, and more than 50 have been identified in California, half of which are commonly found throughout Sutter and Yuba Counties. All mosquitoes that bite humans are capable of transmitting disease to them. Some species are more competent vectors than others. Additionally, new mosquito-vectored diseases are being introduced into the United States as was West Nile virus in 1999. Several species in the District are of particular public health concern, including *Culex tarsalis*, *Culex pipiens*, *Aedes melanimon*, *Aedes sierrensis*, and *Anopheles freeborni*. It is important to understand that all mosquito species have different habitat requirements and behaviors that affect their ability to transmit disease, bite and feed on humans, and be controlled by a specific BMP.



As shown above, all mosquitoes share a similar life cycle representing complete metamorphosis. The mosquito life cycle is best described as a two-stage life cycle, which includes the aquatic stage (larvae and pupae) and the aerial stage (adults). Most Best Management Practices (BMPs) aimed at reducing mosquito populations focus on managing the aquatic stages of the mosquito by creating conditions less favorable for mosquito development or more advantageous for biological control agents such as the mosquitofish (*Gambusia affinis*). This usually involves manipulating the amount or timing of standing water, decreasing the amount of vegetation in and/or around standing water, and creating a situation where natural or introduced predators can consume the mosquito larvae. Since each species of mosquitoes has different habitat requirements, it

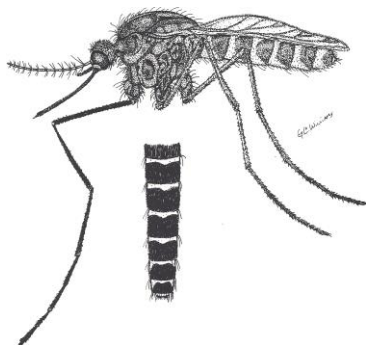
is vital to understand which mosquitoes favor which habitats to realize how a particular BMP is designed to work, thereby reducing mosquito production.

To understand the design of different BMPs, it is useful to think of mosquitoes belonging to one of three categories: standing-water mosquitoes, floodwater mosquitoes, and container mosquitoes. BMPs designed for the reduction of standing-water mosquitoes may not work or be applicable to floodwater mosquitoes and vice versa. Below is a list of each of the three categories of mosquitoes, the mosquitoes of concern commonly found in the District, and common BMPs aimed at the reduction of those mosquitoes.

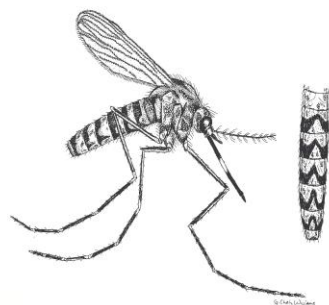
1. **Standing-Water Mosquitoes** prefer still water commonly found in ponds, rice fields, lakes, unmaintained swimming pools, etc.

Mosquito species of concern commonly found in standing-water sources:

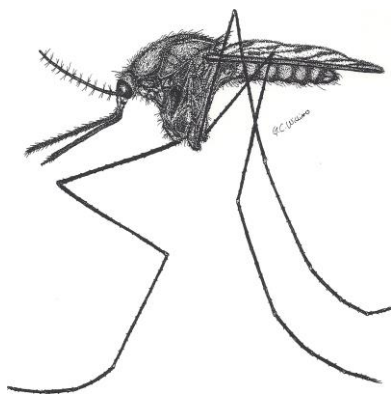
**The Northern House Mosquito** (*Culex pipiens*) is a major vector of West Nile virus (WNV) and can vector Saint Louis encephalitis (SLE) and the Western equine encephalomyelitis (WEE). *Culex pipiens* is an indoor mosquito that breeds primarily in polluted water sources. They are found in ponds, roadside ditches, artificial containers, storm drains, wastewater ponds, sumps, septic tanks, fountains, birdbaths, and un-maintained swimming pools. Birds are their principal blood meal, but they will attack humans and invade their homes. *Culex pipiens* usually breeds in the early spring to late fall in the District. This mosquito is crepuscular, feeding at dawn and dusk. During the summer and fall months or when populations are high, females readily enter residences, feeding on occupants after dark while they sleep. The life cycle can be completed in 10 to 23 days depending on environmental conditions.



**The Encephalitis Mosquito** (*Culex tarsalis*) is the primary vector of West Nile virus (WNV), Saint Louis encephalitis (SLE), and the Western equine encephalomyelitis (WEE). *Culex tarsalis* breeds in a variety of aquatic habitats ranging from clean to polluted water sources, including, but not limited to: flooded agricultural lands, ditches, manmade containers, ponds, and urban sources. In the District, this mosquito breeds yearround and prefers to feed on birds but does readily attack humans, horses, and cattle. This species is crepuscular, feeding at dusk and dawn. The life cycle can be completed in 10 to 23 days depending on environmental conditions.



**The Western Malaria Mosquito** (*Anopheles freeborni*) is one of the District's most



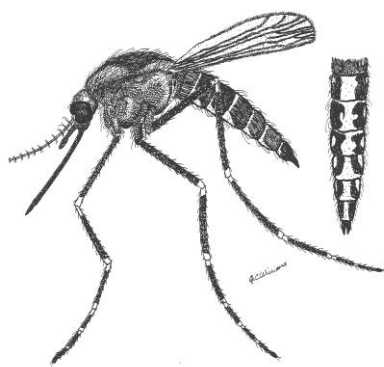
abundant pests and the primary vector of malaria. Larvae prefer clear, fresh water in sunlit or partially shaded pools. This mosquito is most commonly found in rice fields, duck clubs, wetlands, rain pools, vernal pools, and roadside ditches with grass. *Anopheles freeborni* are an aggressive mosquito, commonly feed on mammals or humans, and are most active at dawn and dusk. This species will day-rest in large numbers in shady, cool areas around residences and buildings in the late summer and fall. The life cycle can be completed in 14 to 23 days depending on environmental conditions.

Common BMPs to reduce standing-water mosquitoes:

- a. Drain any and all standing water.
- b. Reduce or eliminate emergent vegetation in and along the edges of water.
- c. Maintain water level to encourage natural predators or biological control agents.
- d. Contact the District to coordinate mosquito prevention with other mosquito control operations such as chemical and biological control.

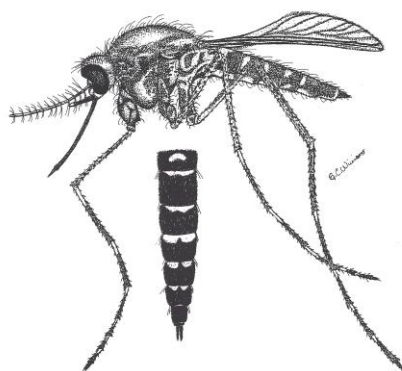
2. **Floodwater Mosquitoes** commonly lay their eggs on moist soil or the base of grasses. When the eggs become submerged as in a seasonal wetland, duck club, irrigated pasture, or flood plane, the eggs hatch.

Mosquito species of concern commonly found in floodwater sources:



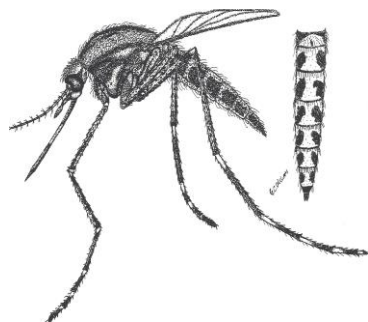
**Wetlands Mosquito** (*Aedes melanimon*) is not only a major pest within twenty miles of its larval breeding sources but is a vector of West Nile virus (WNV) and has been implicated as a secondary vector of Western equine encephalomyelitis (WEE) in the Central and Sacramento Valleys. This species is most commonly found in intermittently flooded areas such as irrigated pastures, duck clubs, and wildlife refuges. *Aedes melanimon* are day-biters that are very aggressive and readily feed on mammals and humans. This species has a relatively short life cycle, which can be completed

in four to 10 days depending on environmental conditions.



**Riparian Woodland Mosquito** (*Aedes vexans*) is a secondary vector for canine heartworm and is a severe outdoor nuisance that is extremely aggressive. It is common in irrigated pastures, orchard drainage, duck clubs, and woodland watercourse pools. They feed primarily on mammals and typically seek blood meals at

dawn and dusk, but will feed all day. This mosquito is most active in early spring through late fall. The life cycle can be completed in 5.5 to 25 days depending on environmental conditions.



**Irrigated Pasture Mosquito** (*Aedes nigromaculis*) is a mosquito species that is a secondary or suspected vector of Western equine encephalomyelitis (WEE) and California group encephalitis. It is commonly found in agricultural sources, especially pastures, wetlands, duck clubs, orchards, and field drains. This mosquito is extremely aggressive and is most active in the spring through fall, feeding on mammals in the days and evenings. This species has a relatively short life cycle, which can be completed in

three to 10 days depending on environmental conditions.

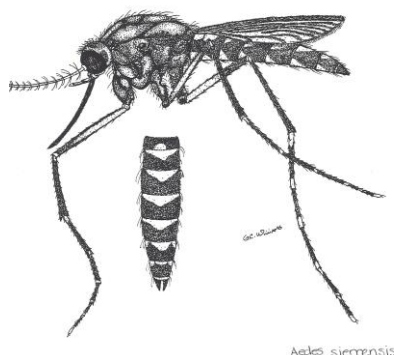
Common BMPs to reduce floodwater mosquitoes:

- a. Flood/irrigate when air temperatures are low and do not encourage rapid mosquito development.
- b. Reduce or eliminate emergent vegetation by disking or mowing (remove debris).
- c. Put water on rapidly and drain rapidly so mosquitoes cannot develop.
- d. Contact the District to coordinate mosquito prevention with other mosquito control operations such as chemical and biological control.

3. **Container Mosquitoes** prefer contained areas of water such as tree holes, buckets, tires, bird baths, fountains, unmaintained swimming pools, rain gutters with clogged downspouts, etc. Many times, standing-water mosquitoes such as the Northern House Mosquito (*Culex pipiens*) and the Encephalitis Mosquito (*Culex tarsalis*) will also breed and develop in container sources.

Mosquito species of concern commonly found in container sources:

Refer to *Culex pipiens* and *Culex tarsalis* above for references as container mosquitoes.



**The Western Treehole Mosquito** (*Aedes sierrensis*) is a major nuisance mosquito usually associated with the foothill regions in Yuba County but routinely identified in some Valley areas. This mosquito is the primary vector of dog heartworm. Larvae are generally found in treeholes and containers that have a lot of leafy material. Eggs hatch with the initial fall rains and overwinter as larvae. This species of mosquito is a very small, aggressive mosquito; that usually surfaces in early spring and is active into the summer months. *Aedes sierrensis* is a vicious biter of humans and other large mammals. The

life cycle can be completed in 15 days or may require months depending on environmental conditions.

**Asian Tiger Mosquito** (*Aedes albopictus*) has not been established in California yet but is an aggressive exotic species that has invaded the eastern and southern United States. Over the past ten years, there have been several cases where this species was found in cargo containers in port areas of Los Angeles and San Francisco. This container-breeding mosquito is of serious concern because of its potential to vector diseases such as Rift Valley Fever, Chikungunya virus, dengue fever, and yellow fever. If *Aedes albopictus* becomes established in California, the need for effective mosquito control practices will be even greater to protect public health. *Aedes albopictus* is an aggressive day-biter that is active in spring, summer, and fall.

Common BMPs to reduce container mosquitoes:

- a. Drain containers of all standing water.
- b. Cover, overturn, or create drainage holes that prevent water from standing in containers.
- c. Identify and prevent sprinklers or other sources of water from refilling containers.
- d. Contact the District to coordinate mosquito prevention with other mosquito control operations such as chemical and biological control.



# IRRIGATION AND DRAINAGE OF AGRICULTURAL SOURCES

The BMPs contained in this manual are assembled from a number of sources including scientific literature, state and inter-agency documents, and experienced vector control professionals. The intended use of this document is to provide general guidance, not site-specific requirements. BMPs that are most applicable to a specific mosquito-breeding source may be selected from the list and incorporated into a specific BMP Implementation Plan for a specific mosquito-breeding source in consultation with District personnel.

## Common Mosquito-Breeding Sites

- Irrigated pastures
- Low areas caused by improper grading
- Broken or leaky irrigation pipes and/or valves
- Vegetated ditches
- Seepage or flooding of fallow fields
- Blocked ditches and/or culverts
- Irrigation tail water return sumps
- Flooded orchards with soil compacted by equipment



## Common Mosquito Species Identified in Above Listed Sites

- Clean standing-water sources: *Culex tarsalis* & *Anopheles freeborni*
- Water that is moderately to highly organic: *Culex pipiens* & *Culex tarsalis*
- Seasonally flooded areas: *Aedes nigromaculis*, *Aedes melanimon* and *Aedes vexans*

## **Special Concerns**

The District is committed to working with agricultural growers to implement mosquito control practices that coincide with agricultural practices and minimize the impact on grower economics or yields of crops. Agricultural practices vary among growers, locations, and conventional or organic production methods. Pesticide regulations can affect the ability to use chemical control products. The following BMPs to reduce mosquito breeding are offered as tools to balance the economic and agronomic requirements of growers and landowners with the need for effective mosquito control.

### **General Practices to Reduce Mosquito Breeding**

1. Prevent or eliminate unnecessary standing water that remains for more than 72 hours during mosquito season. Mosquito season starts when the weather warms and it ends when the weather cools. The typical season for the District is May through October.
2. Maintain access for District staff to monitor and treat mosquito-breeding sources.
3. Minimize emergent vegetation and surface debris on water.
4. Check for occupied habitat of threatened & endangered species before disturbing soil or vegetation. See page 8.
5. Determine if there are impacts to waters of the U.S. or wetlands. See page 8.
6. Contact the District for technical guidance and/or assistance in implementing BMPs to reduce mosquito breeding.

## **BMPS AIMED TO REDUCE MOSQUITO-BREEDING IN AGRICULTURAL SETTINGS**

### **DITCHES AND DRAINS**

- DD-1. Construct or improve ditches with at least 2:1 slopes and a minimum of a four foot bottom. Consider a 3:1 slope or greater to discourage burrowing animal damage and potential seepage problems and to prevent unwanted vegetation growth. Other designs may be approved by the District based on special circumstances.
- DD-2. Keep ditches clean and well maintained. Periodically remove accumulated sediment and vegetation. Maintain ditch grade to prevent areas of standing water.
- DD-3. Design irrigation systems to use water efficiently and drain completely to avoid standing water.

### **IRRIGATED PASTURES**

- IP-1. Grade field to achieve efficient use of irrigation water. Use NRCS guidelines for irrigated pastures. Initial laser leveling and periodic maintenance to repair damaged areas are needed to maintain efficient water flow (Lawler and Lanzaro, 2005).
- IP-2. Irrigate only as frequently as is needed to maintain proper soil moisture. Check soil moisture regularly until you know how your pasture behaves (Lawler and Lanzaro, 2005).
- IP-3. Do not overfertilize. Excess fertilizers can leach into irrigation tail water, making mosquito production more likely in ditches or further downstream (Lawler and Lanzaro, 2005).
- IP-4. Apply only enough water to wet the soil to the depth of rooting (Lawler and Lanzaro, 2005).
- IP-5. Drain excess water from the pasture within 24 hours following each irrigation. This prevents scalding and reduces the number of weeds in the pasture. Good check slopes are needed to achieve drainage. A drainage ditch may be used to remove water from the lower end of the field (Lawler and Lanzaro, 2005).
- IP-6. Inspect fields for drainage and broken checks to see whether re-leveling or reconstruction of levees is needed. Small, low areas that hold water can be filled and replanted by hand. Broken checks create cross-leakage that provides habitat for mosquitoes (Lawler and Lanzaro, 2005).

- IP-7. Keep animals off the pasture while the soil is soft. An ideal mosquito habitat is created in irrigated pastures when water collects in hoofprints of livestock that were run on wet fields or left in the field during irrigation. Keeping animals off wet fields until soil stiffens also protects the roots of forage crop and prevents soil compaction that interferes with plant growth (Lawler and Lanzaro, 2005).
- IP-8. Divide pastures into a number of smaller fields so that animals can be rotated from one field to another. This allows fields to dry between irrigations and provides a sufficient growth period between grazing. It also prevents hoof damage (pugging), increases production from irrigated pastures, and helps improve water penetration into the soil by promoting a better root system (Lawler and Lanzaro, 2005).

## DAIRIES

### Common Mosquito-Breeding Sites

- Wastewater lagoons
- Animal washing areas
- Drain ditches
- Sumps/ponds
- Watering troughs
- Irrigated pastures
- Irrigated crops

### Common Mosquito Species Identified in Above-Listed Sites

- Clean standing-water sources: *Culex tarsalis*
- Nutrient-rich water sources: *Culex pipiens* & *Culex stigmatosoma*

### Special Concerns

Dairy and associated agricultural practices vary; however, these practices need to take into account mosquito and vector control issues. The BMPs for mosquito reduction below offer options to balance the requirements of dairy operators with the need for effective mosquito control. The District is committed to working with dairy operators to implement mosquito control practices that are effective and have the least possible impact on the economics and operation of the dairy.

### General Practices to Reduce Mosquito Breeding

1. Prevent or eliminate unnecessary standing water that remains for more than 72 hours during mosquito season. Mosquito season starts when the weather warms, and it ends when the weather cools. The typical season for the District is May through October.
2. Maintain access for District staff to monitor and treat mosquito-breeding sources.
3. Minimize emergent vegetation and surface debris on the water.
4. Check for occupied habitat of threatened & endangered species before disturbing soil or vegetation. See page 8.
5. Determine if there are impacts to waters of the U.S. or wetlands. See page 8.
6. Contact the District for technical guidance and/or assistance in implementing BMPs to reduce mosquito breeding.

## **BMPS AIMED TO REDUCE MOSQUITO-BREEDING IN DAIRIES**

- DA-1. Wastewater holding ponds should not exceed 150' in width.
- DA-2. Maintain paths and/or roads of adequate width to allow safe passage of vector control equipment. Paths and/or roads should surround all holding ponds. This includes keeping the lanes clear of any materials or equipment (e.g., trees, calf pens, hay stacks, silage, tires, equipment, etc.).
- DA-3. If fencing is used around holding ponds, it should be placed on the outside of the paths and/or roads, with gates provided for vehicle access.
- DA-4. All interior banks of the holding ponds should have a grade of at least 2:1.
- DA-5. 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 sixty feet in surface width.
- DA-6. If two or more ponds are used as drainage and/or solid separators, the landowner/manager must coordinate with the District to propose a management plan to coordinate the use of these ponds. Such a plan will include vegetation management, coordinated pond drying, and solids removal.
- DA-7. Drainage lines should never bypass the separator ponds, except those that provide for normal corral runoff and do not contain solids. All drain inlets must be sufficiently graded to prevent solids accumulation.
- DA-8. Floating debris should be eliminated on all ponds; mechanical agitators may be used to break up crusts.
- DA-9. Vegetation should be controlled regularly to prevent emergent vegetation and barriers to access. This includes access paths and/or roads, interior pond embankments and any weed growth that might become established within the pond surface. An approved vegetation management plan should be on file with the District.
- DA-10. Dairy wastewater discharged for irrigation purposes should be managed so that it does not remain for more than 72 hours.
- DA-11. All structures and water management practices should meet current California Regional Water Quality Control Board requirements (Creedon, 2006).
- DA-12. 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.



## RICE FIELDS



### Common Mosquito-Breeding Sites

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.

Organic rice production limits the chemical control materials available, so additional attention to BMPs is critical.

- Leaky levees
- Weedy borrow pits and field borders
- Irrigation and drain ditches
- Post-harvest reflooded rice for organic decomposition

### Common Mosquito Species Identified in Above Listed Sites

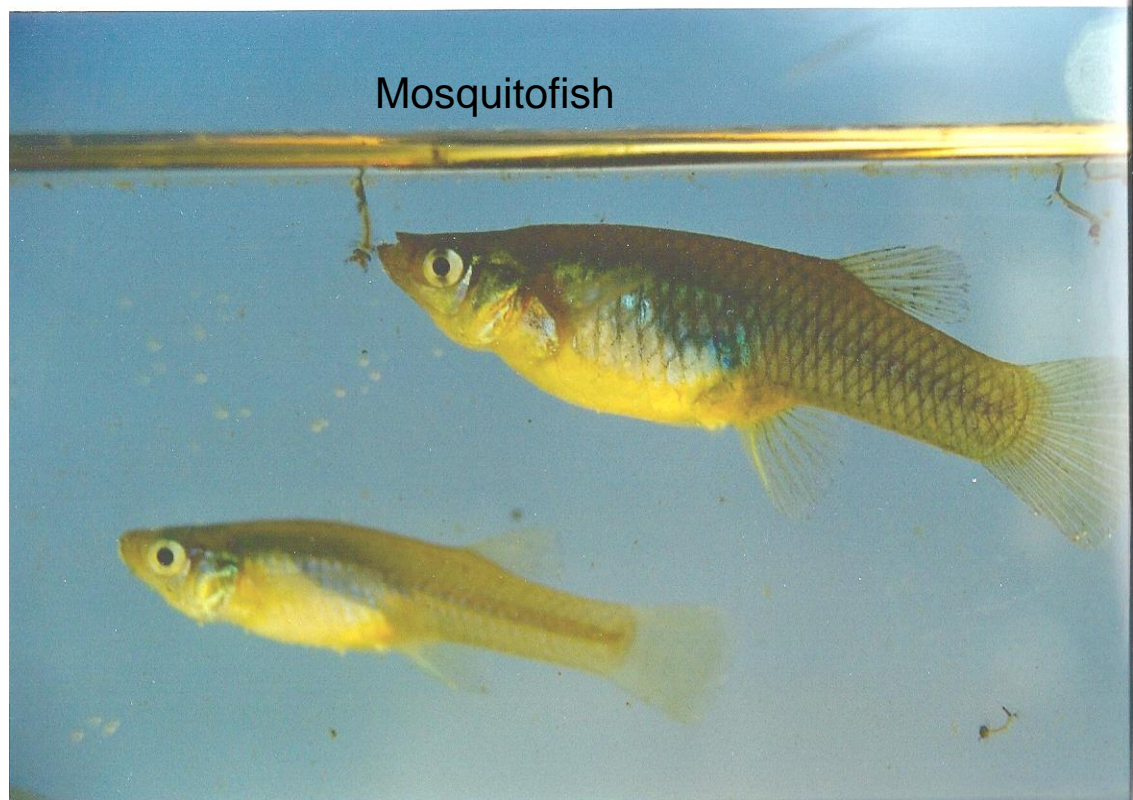
- *Culex tarsalis*
- *Anopheles* species
- *Aedes melanimon* & *Culiseta inornata* (post-harvest reflood)

### Special Concerns

1. Check for occupied habitat of threatened & endangered species before disturbing soil or vegetation. See page 8.
2. Determine if there are impacts to waters of the U.S. or wetlands. See page 8.

Agricultural practices vary among growers, locations, and conventional or organic production methods. Also, local differences in environmental conditions may affect mosquito production from field to field. The BMPs below try to balance the economic and agronomic requirements of the growers and landowners with the need for effective mosquito control. The District is committed to continued work with growers, the California Rice Commission and other stakeholders to develop and implement mosquito control practices that coordinate with standard rice production practices and minimize the impact on the economics or yields of the crop.

The need for close cooperation with all rice growers is important, but it is especially important with growers who produce organic rice. At this time, there are only two available mosquito larvicides for organic rice, which leaves biological control (mosquitofish), physical control (weed control) and cultural control (water management) as the only remaining mosquito management tools. Because proper timing and planning is essential for an effective IMM program, the District asks organic rice growers for an added level of commitment to addressing mosquito control issues in a cooperative manner.



## **BMPS AIMED TO REDUCE MOSQUITO-BREEDING IN RICE FIELDS**

### **Conventional Rice Production**

- RI-1. Wherever feasible, maintain stable water level during mosquito season by ensuring constant flow of water into pond or rice fields to reduce water fluctuation due to evaporation, transpiration, outflow, and seepage (Lawler and Lanzaro, 2005).
- RI-2. Inspect and repair levees to minimize seepage (Lanzaro and Lawler, 2005; Lawler, 2005).
- RI-3. Drain and eliminate borrow pits and seepage areas external to the fields (Lanzaro and Lawler, 2005; Lawler, 2005).
- RI-4. Wherever feasible, maintain at least 4"-6" of water in the rice field after rice seedlings have begun to stand upright. Planned drainages should be coordinated with the District. If an unplanned drainage is necessary, notify the District as soon as possible to coordinate restocking of mosquitofish or to use alternative mosquito control measures.
- RI-5. Wherever feasible, control vegetation on the outer most portions of field levees and checks, specifically where they interface with standing water (Lanzaro and Lawler, 2005; Lawler, 2005).
- RI-6. Control algae and weed growth as effectively as possible (Lawler, 2005).
- RI-7. Communicate frequently with the District regarding your crop management activities. For example: draw-down of water levels, except drainage for harvest; any drainage of fields to fallow fields; initiation of post-harvest flooding for straw management or habitat objectives.
- RI-8. Design fields with sufficient borrow pits along each internal levee to promote efficient drainage, and provide refuge for mosquitofish during low water.
- RI-9. Notify the District prior to any pyrethroid insecticide applications to rice fields stocked with mosquitofish. The pyrethroid insecticides that can be applied to rice fields include lambda cyhalothrin (Warrior® Insecticide, Karate® Insecticide) or s-cypermethrin (Mustang® Insecticide) (Lanzaro and Lawler, 2005; Lawler, 2005).
- RI-10. Notify the District 14 days prior to any propanil application due to interaction with some organophosphate insecticides the District may apply to the rice field.

### **Organic Rice Production (Includes Fulfilling Required BMPs RI-1 to RI-10)**

RI-11. Post-harvest rice field reflooding for organic decomposition should commence after seasonal temperatures have cooled substantially so that field conditions are not conducive to mosquito production. This is generally after October 1st.

RI-12. Wherever feasible, maintain borrow pits (12"-18" deep) on both sides of each check throughout rice fields to provide refuge for mosquitofish during low water periods.



# STORM-WATER SYSTEMS

## Common Mosquito-Breeding Sites

- Detention/retention basins/ponds
- Treatment wetlands
- Catch basins/storm drains
- Underground water storage devices
- Combined sewer systems
- Clogged sediment screens
- Blocked culverts
- Roadside ditches
- Beaver dams

## Common Mosquito Species Identified in Above Listed Sites

- Above-ground/clean-water sources: *Culex tarsalis*
- Underground/polluted or nutrient-rich water: *Culex pipiens*



Storm Water Drain

## Special Concerns

The National Pollution Discharge Elimination System (NPDES) permit requirements have established a new emphasis on storm-water handling. Storm-water facilities are often ideal mosquito-development sites and support large populations of vectors of diseases such as West Nile virus in close proximity to urban and residential areas. It is critical to consider mosquito production in storm-water structures at the planning stages of new development and to identify appropriate actions to address mosquito problems in



existing facilities. Coordination with the NPDES program will be critical in the success of this endeavor.

### **General Practices to Reduce Mosquito Breeding**

1. Prevent or eliminate unnecessary standing water that stands for more than 72 hours during mosquito season. Mosquito season starts when the weather warms, and it ends when the weather cools. The typical season for the District is May through October.
2. Maintain access for District staff to monitor and treat mosquito-breeding sources.
3. Minimize emergent vegetation and surface debris on the water.
4. Check for occupied habitat of threatened & endangered species before disturbing soil or vegetation. See page 8.
5. Determine if there are impacts to waters of the U.S. or wetlands. See page 8.
6. Contact the District for technical guidance and/or assistance in implementing BMPs to reduce mosquito-breeding.





## **BMPS AIMED TO REDUCE MOSQUITO-BREEDING IN STORM-WATER SYSTEMS**

### **Aboveground Storm-Water Structures (Retention Detention Ponds, Storm-Water Ponds)**

- SW-1. Build shoreline perimeters as steep and uniform as practicable to discourage dense plant growth (Metzger, 2004).
- SW-2. Whenever possible, maintain storm water ponds and wetlands at depths in excess of four feet (1.2m) to limit the spread of invasive emergent vegetation such as cattails (*Typha* spp.) (Kwasny et al., 2004; Metzger, 2004).
- SW-3. Eliminate floating vegetation conducive to mosquito production (e.g., water hyacinth, *Eichhornia* spp., duckweed *Lemna* and *Spirodela* spp., and filamentous algal mats) (Metzger, 2004).
- SW-4. Perform routine maintenance to reduce emergent plant densities to facilitate the ability of mosquito predators (i.e., mosquitofish) to move throughout vegetated areas (Metzger, 2004).
- SW-5. Make shorelines accessible to maintenance and vector control crews for periodic maintenance, control, and removal of emergent vegetation, as well as for routine mosquito monitoring and abatement procedures, if necessary (Metzger, 2004).
- SW-6. Design and obtain necessary approvals for all storm-water ponds and wetlands to allow for complete draining when needed (Metzger, 2004).
- SW-7. The effective swath width of most backpack or truck-mounted larvicide sprayers is approximately 20 feet (6m) on a windless day. Because of these equipment limitations, all-weather road access (with provisions for turning a full-size work vehicle) should be provided along at least one side of large aboveground structures that are less than 25 feet (7.5m) wide (Metzger, 2004).
- SW-8. Access roads should be built as close to the shoreline as possible. Vegetation or other obstacles should not be permitted between the access road and the storm-water treatment device that might obstruct the path of larvicides to the water (Metzger, 2004).
- SW-9. Vegetation should be controlled (by removal, thinning, or mowing) periodically to prevent barriers to access (Metzger, 2004).
- SW-10. Design structures so they do not hold standing water for more than 72 hours. Special attention to groundwater depth is essential (Metzger, 2004).

- SW-11. Use the hydraulic grade line of the site to select a treatment BMP that allows water to flow by gravity through the structure. Pumps are not recommended because they are subject to failure and often require sumps that hold water (Metzger, 2004).
- SW-12. Avoid the use of loose riprap or concrete depressions that may hold standing water (Metzger, 2004).
- SW-13. Avoid barriers, diversions, or flow spreaders that may retain standing water (Metzger, 2004).
- SW-14. Use concrete or liners in shallow areas to discourage unwanted plant growth where vegetation is not necessary (Metzger, 2004).
- SW-15. Where feasible, compartmentalize managed treatment wetlands so that the maximum width of ponds does not exceed two times the effective distance (40 feet [12m]) of land-based application technologies for mosquito control agents (Walton, 2003).
- SW-16. Incorporate features that prevent or reduce the possibility of clogged discharge orifices (e.g., debris screens). The use of weep holes is not recommended due to rapid clogging (Metzger, 2004).
- SW-17. Design distribution piping and containment basins with adequate slopes to drain fully and prevent standing water. The design slope should take into consideration buildup of sediment between maintenance periods. Compaction during grading may also be needed to avoid slumping and settling (Metzger, 2004).
- SW-18. Catch basins, drop inlets, storm drains, and other structures originally designed to not hold water should be regularly checked and maintained to function as designed.
- SW-19. Basins designed to be dry but remaining wet should be corrected by retrofit, replacement, repair, or more frequent maintenance.
- SW-20. Coordinate cleaning of catch basins, drop inlets, or storm drains with mosquito treatment operations.
- SW-21. Enforce the prompt removal of silt screens installed during construction when no longer needed to protect water quality.

### **Underground Storm-Water Structures (Drain Inlets, Sumps, Vaults, Catch Basins)**

- SW-22. Completely seal structures that retain water permanently or longer than 72 hours to prevent entry of adult mosquitoes (Metzger, 2004).

SW-23. Storm-water structures utilizing covers should be tight-fitting with maximum allowable gaps or 1/16-inch (2mm) holes to exclude entry of adult mosquitoes (Metzger, 2004).

SW-24. If the sump, vault, or basin is sealed against mosquitoes, with the exception of the inlet and outlet submerge the inlet and outlet completely to reduce the available surface area of water for mosquito egg-laying (female mosquitoes can fly through pipes) (Metzger, 2004).

SW-25. Design structures with the appropriate pumping, piping, valves, or other necessary equipment to allow for easy dewatering of the unit when necessary (Metzger, 2004).

SW-26. Coordinate with the District catch-basin cleaning performed between May and October. Mosquito larval control products such as briquets or strips may have to be reapplied.

## MANAGED WETLANDS



Wildlife Refuge

### Common Mosquito-Breeding Sites

- Permanent wetlands for habitat or species conservation
- Constructed vernal pools and other wetlands
- Seasonal wetlands
- Duck clubs

### Common Mosquito Species Identified in Above Listed Sites

- Permanent wetlands and duck clubs: *Culex tarsalis*, *Culex erythrothorax* & *Anopheles freeborni*
- Seasonal wetlands and duck clubs: *Aedes melanimon*

### Special Concerns

Managed wetlands are being built and restored across northern California. Each varies depending on the habitat, water quality, and recreational, economic, and other management goals, and may be subject to additional regulations including state and federal conservation easements and management plans. BMPs aimed at the reduction of mosquito breeding attempt to balance the management goals of land managers,

landowners, and other regulatory agencies with the need for effective mosquito control. The District is committed to working with wetland managers and state and federal agencies to implement mosquito control practices in a cooperative manner.

### **General Practices to Reduce Mosquito Breeding**

1. Prevent or eliminate unnecessary standing water that stands for more than 72 hours during mosquito season. Mosquito season starts when the weather warms, and it ends when the weather cools.
2. Maintain access for District staff to monitor and treat mosquito-breeding sources.
3. Minimize emergent vegetation and surface debris on the water.
4. Check for occupied habitat of threatened & endangered species before disturbing soil or vegetation. See page 8.
5. Determine if there are impacts to waters of the U.S. or wetlands. See page 8.
6. Contact the District for technical guidance and/or assistance in implementing BMPs to reduce mosquito breeding.

## **BMPS AIMED TO REDUCE MOSQUITO BREEDING IN MANAGED WETLANDS**

### **Wetland Design and Maintenance**

- MW-1. Maintain all open ditches by periodically removing trash, silt, and vegetation to maintain efficient water delivery and drainage (Kwasny et al., 2004).
- MW-2. Provide reasonable access on existing roads and levees to allow mosquito abatement technicians access for monitoring, abatement, and implementation of BMPs. Make shorelines of natural, agricultural, and constructed water bodies accessible to maintenance and vector control crews for periodic maintenance, control, and removal of emergent vegetation, as well as for routine mosquito monitoring and abatement procedures (Kwasny et al., 2004).
- MW-3. Inspect, repair, and clean water control structures of debris. Remove silt and vegetation build-up in front of structures that impedes drainage or water flow. Completely close, board or mud-up controls to prevent unnecessary water seepage, except where water circulation is necessary (Kwasny et al., 2004).
- MW-4. Perform regular pump efficiency testing and make any necessary repairs to maximize output (Kwasny et al., 2004).
- MW-5. Construct, improve, or maintain ditches with 2:1 slopes and a minimum 4-foot bottom. Consider a 3:1 slope or greater to discourage burrowing animal damage, potential seepage problems, and unwanted vegetation growth (Kwasny et al., 2004). Other designs may be approved by the District depending on special circumstances.
- MW-6. Construct, improve, or maintain levees to a quality standard that ensures stability and prevents 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 (Kwasny et al., 2004).
- MW-7. Ensure that adequately-sized water control structures are in place. Increase size and number of water control structures if necessary to allow for complete draw-down and rapid flooding (Kwasny et al., 2004; Walton, 2003).
- MW-8. Inspect and repair levees at least annually (Kwasny et al., 2004).
- MW-9. Design managed wetland projects to include independent inlets and outlets for each wetland unit (Kwasny et al., 2004).
- MW-10. Construct or enhance swales so they are sloped from inlet to outlet and allow the majority of the wetland to be drawn down (Kwasny et al., 2004).



- MW-11. Install cross-levees to facilitate more rapid irrigation and flood-up. Build “underwater” levees that isolate irrigation water during the spring but can be overtopped during fall and winter flooding (Kwasny et al., 2004).
- MW-12. 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, which can inoculate seasonal wetlands when they are irrigated or flooded (Kwasny et al., 2004).
- MW-13. Maintain separate permanent water reservoir that conveys water to seasonal wetlands. This provides year-round habitat for mosquito predators which can inoculate seasonal wetlands when they are irrigated or flooded (Kwasny et al., 2004).
- MW-14. Encourage populations of insectivorous birds (e.g., swallows) and bats by preserving nesting and roosting areas (Kwasny et al., 2004).

### **Wetland Vegetation Management**

- MW-15. Control floating vegetation conducive to mosquito production (i.e., water hyacinth, water primrose, parrot’s feather *Eichhornia* spp., duckweed *Lemna* and *Spirodela* spp., and filamentous algal mats) (Metzger, 2004).
- MW-16. Perform routine maintenance to reduce problematic emergent plant densities to facilitate the ability of mosquito predators (i.e., fish) to move throughout vegetated areas and to allow good penetration of chemical control agents (Kwasny et al., 2004).

### **Wetland Water Management**

- MW-17. Maintain stable water level during mosquito season by ensuring constant flow of water into pond or wetland to reduce water fluctuation due to evaporation, transpiration, outflow, and seepage (Kwasny et al., 2004; Walton, 2003).
- MW-18. Flood managed wetlands with water sources containing mosquitofish or other invertebrate predators. Water from permanent ponds can be used to introduce mosquito predators passively (Kwasny et al., 2004).
- MW-19. Rapidly irrigate wetlands, keeping the time water enters the pond to complete drawdown between four and 10 days (Kwasny et al., 2004).
- MW-20. Extended duration irrigations (generally 14-17 days) may be considered for weed control (e.g. cocklebur). Additional measures to offset the potential for increased mosquito production may be needed.
- MW-21. Delay fall flooding to avoid increasing late-season mosquito production. (Kwasny et al., 2004).



- MW-22. Implement additional BMPs for wetlands that need to be flooded earlier than recommended in the fall. The wetlands targeted for early fall flooding should not be near urban centers and should not have a history of heavy mosquito production (Kwasny et al., 2004). Additionally, choose wetlands that have a history of low mosquito production.
- MW-23. Flood managed wetland unit as fast as possible. Coordinate flooding with neighbors or water district to maximize flood-up rate (Kwasny et al., 2004).
- MW-24. Encourage water circulation by providing a constant flow of water equal to discharge at drain structure (Kwasny et al., 2004).
- MW-25. Flood managed wetland as deep as possible at initial flood-up (18-24"). Shallow water levels can be maintained outside of the mosquito breeding season. (Kwasny et al., 2004).
- MW-26. Drain irrigation water into ditches or other water bodies with abundant mosquito predators. Prevent free flooding into fallow or dry fields (Kwasny et al., 2004).
- MW-27. Use a flood-drain-flood regime to control floodwater mosquitoes. Flood wetland to hatch larvae in the pond. Drain wetland to borrow or other ditch where larvae can be easily treated, drowned in moving water, or consumed by predators. Immediately reflood wetland. (Kwasny et al., 2004). Note: This water management regime should be used only when it does not conflict with water quality regulations.
- MW-28. Evaluate necessity of irrigation, especially multiple irrigations, based on spring habitat conditions and plant growth. Reduce number and duration of irrigations when feasible (Kwasny et al., 2004).
- MW-29. Where feasible, drawdown managed wetland in late March or early April. Irrigate in late April or early May when weather is cooler and mosquitoes are less of a problem (Kwasny et al., 2004).
- MW-30. Irrigate managed wetland before soil completely dries to prevent soil cracking between spring drawdown and irrigation (Kwasny et al., 2004).
- MW-31. Stock managed wetlands, especially brood ponds or permanent wetlands, with mosquitofish or encourage habitat for naturalized populations. Utilize water sources with mosquitofish to transport predators passively to newly flooded habitats (Kwasny et al., 2004).
- MW-32. Maintain permanent or semipermanent water where mosquito predators can develop and be maintained. Discourage use of broad spectrum pesticides (Kwasny et al., 2004).

MW-33. Where feasible, have an emergency plan that provides for immediate drainage into acceptable areas if a public health emergency occurs (Walton, 2003).

MW-34. Minimize fluctuations in water level to prevent large areas of intermittently flooded substrate or isolated pools from being created, particularly during mosquito season, which can start as early as March and extend through October depending on weather (Kwasny et al., 2004).

### **Coordination with the District**

MW-35. Consult with the District on agency-sponsored habitat management plans on private lands (e.g. Presley Program); on the timing of wetland flooding on public and private lands, urge private landowners to do the same (Kwasny et al., 2004).

MW-36. Identify problem locations for mosquito production with the District and work to implement mosquito BMPs. Identify potential cost-share opportunities to implement BMPs (Kwasny et al., 2004).

MW-37. Consult with the District on the design of restoration and enhancement projects that have the possibility of affecting mosquito production or control operations (Kwasny et al., 2004).

## URBAN AND SUBURBAN MOSQUITO-BREEDING SOURCES



### Common Mosquito Breeding Sites

- Unmaintained swimming pools and spas
- Decorative ponds and fountains
- Bird baths
- Water-filled containers
- Clogged rain gutters
- Poorly designed or damaged landscape irrigation systems
- Cemetery vases
- Ornamental and/or Koi ponds
- Stored or waste tires

### Common Mosquito Species Identified in Above-Listed Sites

- Cleaner water sources: *Culex tarsalis*
- Water with more organic material: *Culex pipiens* & *Culex stigmatosoma*
- Containers with high organic material: *Aedes sierrensis*



**Special Concerns** Urban and suburban mosquito sources are especially important because sources may be in and around private residences that are not easily seen or accessed by mosquito and vector control specialists and may produce mosquitoes in areas of high population density. This can quickly lead to vector-borne disease transmission since the vector (mosquito) and host (human) are often in close proximity. Most urban and suburban mosquito species produced are the species of mosquito that are of highest importance due to their more-than- favorable ability to transmit WNV. Economic or social changes in a neighborhood can result in an increase in mosquito sources such as unmaintained swimming pools. Fortunately, most BMPs for residential areas are relatively inexpensive and easy to implement.

### **General Practices to Reduce Mosquito Breeding**

1. Prevent or eliminate unnecessary standing water that stands for more than 72 hours during mosquito season. Mosquito season starts when the weather warms, and it ends when the weather cools. The typical season for the District is May through October.
2. Maintain access for District staff to monitor and treat mosquito-breeding sources.
3. Minimize emergent vegetation and surface debris on the water.
4. Check for occupied habitat of threatened & endangered species before disturbing soil or vegetation. See page 8.
5. Determine if there are impacts to waters of the U.S. or wetlands. See page 8.
6. Contact the District for technical guidance and/or assistance in implementing BMPs to reduce mosquito-breeding.







# **BMPS AIMED TO REDUCE MOSQUITO BREEDING IN URBAN AND SUBURBAN SOURCES**

## **Urban and Suburban Residential Areas**

- US-1. Drain all containers of standing water, including pet dishes, wading pools, potted plant drip trays, boats, birdbaths, tires, and buckets, at least once a week during mosquito season. Keep in mind that mosquitoes can develop in as little as 1/8" of standing water.
- US-2. Use an approved disinfection process (chlorine, bromine) to prevent mosquito breeding in swimming pools and spas. Use skimmers and filter systems to remove egg rafts and mosquito larvae.
- US-3. If a pool or spa is not going to be maintained for any reason, do one of the following: 1) Drain the pool or spa completely of any water. (Note that in-ground pools may be damaged by being completely drained. Above-ground pools and spas generally may be drained without damage.) 2) Notify the District so that the pool can be inspected regularly and treated with a larvicide and/or stocked with mosquitofish if needed.
- US-4. Notify the District of any ponds (including ponds with ornamental fish such as koi or goldfish) with permanent or seasonally permanent water. Allow District technicians to inspect and periodically stock mosquitofish or guppies to control mosquito larvae biologically.
- US-5. Landscape irrigation drainage should be managed such that no water stands for more than 72 hours during mosquito-breeding season.
- US-6. All underground drain-pipes should be laid to grade to avoid low areas that may hold water for longer than 72 hours.
- US-7. Keep rain gutters clear of leaves and debris. Check for standing water in gutters after rain events during mosquito season.
- US-8. Provide safe access for District technicians to all pools, spas, ponds, landscape irrigation structures, catch basins, storm drains, drainage pipes, sewer cleanouts, or any other potential mosquito-breeding source.
- US-9. Repair leaks or damaged drainage system components to prevent standing water for more than 72 hours during mosquito season.
- US-10. Notify District of any condition that may produce mosquitoes on the property such as flooding, broken pipe, damaged septic tank cover, or leaking outdoor faucet if unable to be fixed or if it results in standing water for more than 72 hours during mosquito season.

## **Tire Storage**

- TR-1. Never allow water to accumulate in tires. Tires should be stored in a covered location or covered by a tarp in order to prevent the accumulation of water from rain, sprinklers, etc.
- TR-2. Tires should never be stored in a pile. Tires should be stored on racks or in a stack not more than two rows wide.
- TR-3. Tires should be stored in a manner that allows inspection of each individual tire.
- TR-4. Waste tires should be picked up by the proper disposal entity on a regular basis.
- TR-5. Those responsible for stored tires should inspect for and dump out any water that may have accumulated inside tires on their premises on a weekly basis.
- TR-6. Tires used for boundary markers should be cut in half or have one-inch or larger holes drilled in lower side walls to prevent water accumulation.

## **Cemetery Flower Vases**

- CV-1. Use a water-absorbing polymer material (super-absorbent polyacrylamide), which turns standing water into a gel. This eliminates the chance of mosquito development, yet allows cut flowers to remain fresh.
- CV-2. Seek alternatives to in-ground or mounted flower vases that can hold water for 72-96 hours.
- CV-3. Dump out all vases weekly during the spring, summer, and fall.
- CV-4. Consider drilling holes in vases that sit in/on a permeable substrate such as soil.



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Best Management Practices for mosquito control on California state properties. June 2008, California Department of Public Health.

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## Appendix “A”

**Wildlife listed as state or federally threatened or endangered or as a CDFG species of special concern in Sutter or Yuba Counties. Source: CNDDDB 2011, NMFS 2009, USFWS 1994.**

Common Name ( <i>Scientific Name</i> )	Federal Status	State Status	Habitat Requirements	Habitat within District?	Known Occurrences in District?*/Closest Occurrence*
Conservancy Fairy Shrimp ( <i>Branchinecta conservatio</i> )	Endangered		Vernal Pools	Yes	No/SE 1.6 miles
Vernal Pool Tadpole Shrimp ( <i>Lepidurus packardii</i> )	Endangered		Vernal Pools	Yes	Yes
Vernal Pool Fairy Shrimp ( <i>Branchinecta lynchi</i> )	Threatened		Vernal Pools	Yes	Yes
Chinook Salmon - Central Valley Spring-run ESU ( <i>Oncorhynchus tshawytscha</i> )	Threatened	Threatened	Estuarine, Marine, Riverine	Yes	Yes <sup>1</sup>
Chinook Salmon – Sacramento River Winter-run ESU ( <i>Oncorhynchus tshawytscha</i> )	Endangered	Endangered	Estuarine, Marine, Riverine	Yes	Yes <sup>1</sup>
Delta Smelt ( <i>Hypomesus transpacificus</i> )	Threatened	Threatened	Estuarine , Riverine	Yes	No/S 28.2 miles
California Tiger Salamander ( <i>Ambystoma californiense</i> )	Threatened	Threatened, Species of Concern	Grasslands, Oak Woodlands, Coniferous forest	Yes	Yes <sup>2</sup>
Giant Garter Snake ( <i>Thamnophis gigas</i> )	Threatened	Threatened	Freshwater Emergent Wetlands Irrigated Row and Field Crops, Riverine, Shoreline, Valley-Foothill Riparian	Yes	Yes
Central Valley Steelhead ( <i>Oncorhynchus mykiss</i> )	Threatened		Estuarine, Marine, Riverine	Yes	Yes <sup>1</sup>
Green Sturgeon ( <i>Acipenser medirostris</i> )	Threatened	Species of Concern	Estuarine, Marine, Riverine	Yes	No/NW 159 miles

Common Name ( <i>Scientific Name</i> )	Federal Status	State Status	Habitat Requirements	Habitat within District?	Known Occurrences in District?*/Closest Occurrence*
California Red-legged Frog ( <i>Rana draytonii</i> )	Threatened	Species of Concern	Freshwater Emergent Wetlands, Lacustrine, Riverine, Shoreline, Valley- Foothill Riparian, Wet Meadows	Yes	No <sup>2</sup> / E 17.7 miles
Valley Elderberry Longhorn Beetle ( <i>Desmocerus californicus dimorphus</i> )	Threatened		Blue Oak Woodlands, Blue Oak-Foothill Pine, Valley-Foothill Riparian	Yes	Yes
Mountain Plover ( <i>Charadrius montanus</i> )	Proposed Threatened	Species of Concern	Alkali Desert Scrub, Annual Grasslands, Croplands	Yes	No/W 1.2 miles
Western Yellow-billed Cuckoo ( <i>Coccyzus americanus occidentalis</i> )	Candidate	Endangered	Desert Riparian, Valley-Foothill Riparian	Yes	Yes
Pacific Fisher ( <i>Martes pennanti (pacifica) DPS</i> )	Candidate	Species of Concern	Mixed Hardwood and Conifer Forests	No	No/E 16.2 miles
Bald Eagle ( <i>Haliaeetus leucocephalus</i> )		Endangered	Riverine, Lacustrine, Marine	Yes	Yes <sup>3</sup>
Greater Sandhill Crane ( <i>Grus canadensis tabida</i> )		Threatened	Annual Grasslands, Croplands, Freshwater Emergent Wetlands, Lacustrine, Perennial Grasslands, Wet Meadows	Yes	Yes
California Black Rail ( <i>Laterallus jamaicensis coturniculus</i> )		Threatened	Freshwater Emergent Wetland, Saline Emergent Wetland	Yes	Yes

Common Name ( <i>Scientific Name</i> )	Federal Status	State Status	Habitat Requirements	Habitat within District?	Known Occurrences in District?*/Closest Occurrence*
Swainson's Hawk ( <i>Buteo swainsoni</i> )		Threatened	Annual Grasslands, Blue Oak Woodlands, Croplands, Pastures, Perennial Grasslands, Valley Oak Woodlands, Valley-Foothill, Riparian	Yes	Yes
Foothill Yellow-legged Frog ( <i>Rana boylei</i> )		Species of Concern	Riverine, Shoreline	Yes	No <sup>2</sup> / E 16 miles
Western Spadefoot ( <i>Spea hammondi</i> )		Species of Concern	Annual Grasslands, Blue Oak-Foothill Pine, Coastal Scrub, Freshwater Emergent Wetlands, Mixed Chaparral Riverine, Vernal Pools	Yes	No/ E 4.4 miles
Sacramento Splittail ( <i>Pogonichthys macrolepidotus</i> )		Species of Concern	Estuarine, Riverine	Yes	Yes
Western Pond Turtle ( <i>Emys marmorata</i> )		Species of Concern	Riverine, Lacustrine, Fresh Emergent Wetlands, Vernal Pools, Agricultural Ditches, Estuaries	Yes	Yes
Tricolored Blackbird ( <i>Agelaius tricolor</i> )		Species of Concern	Annual Grasslands, Croplands, Freshwater Emergent Wetlands, Pastures, Perennial Grasslands	Yes	Yes
Grasshopper Sparrow ( <i>Ammodramus savannarum</i> )		Species of Concern	Annual Grasslands, Pastures, Perennial Grasslands	Yes	No/NE 3.8 miles
Long-eared Owl ( <i>Asio otus</i> )		Species of Concern	Grasslands, Montane Chaparral, Riparian, Agriculture, Freshwater Emergent Wetlands	Yes	No/NE 5.7 miles
Burrowing Owl ( <i>Athene cunicularia</i> )		Species of Concern	Annual Grassland, Coastal Scrub, Coastal Terrace Prairies, Desert Scrub, Perennial Grasslands, Sagebrush	Yes	Yes

Common Name ( <i>Scientific Name</i> )	Federal Status	State Status	Habitat Requirements	Habitat within District?	Known Occurrences in District?*/Closest Occurrence*
Northern Harrier ( <i>Circus cyaneus</i> )		Species of Concern	Grasslands, Freshwater Emergent Marshes, Agricultural, Riparian	Yes	No/N 0.8 miles
Yellow Warbler ( <i>Dendroica petechia brewsteri</i> )		Species of Concern	Montane Riparian, Valley-Foothill Riparian	Yes	No/NE 5.5
Marysville California Kangaroo Rat ( <i>Dipodomys californicus eximius</i> )		Species of Concern	Annual Grasslands, Mixed Chaparral	Yes	No/N 0.6 miles
Purple Martin ( <i>Progne subis</i> )		Species of Concern	Grasslands, Riverine, Riparian	Yes	No/SE 8.1
Bank Swallow ( <i>Riparia riparia</i> )		Threatened	Valley-Foothill Riparian	Yes	Yes
Pallid Bat ( <i>Antrozous pallidus</i> )		Species of Concern	Barren, Grasslands	Yes	No/W 2.4 miles
Western Red Bat ( <i>Lasiurus blossevillii</i> )		Species of Concern	Blue Oak-Foothill Pine, Jeffrey Pine, Montane Hardwood-Conifer, Montane Riparian, Orchards and Vineyards	Yes	Yes

ESU = evolutionarily significant unit. \* according to CNDDB unless otherwise noted; <sup>1</sup> based on NMFS 2009; <sup>2</sup> presumed extirpated from historical habitat, <sup>3</sup> based on USFWS 1994.

**Sensitive plant species of Sutter and Yuba Counties. Source: CNDDDB 2011.**

<b>Common Name (Scientific Name)</b>	<b>Federal Status</b>	<b>State Status</b>	<b>Habitat Requirements</b>	<b>Habitat within District?</b>	<b>Known Occurrences within District?</b>
Ferris' Milk-vetch ( <i>Astragalus tener</i> var. <i>ferrisiae</i> )	-	CNPS 1B.1	Meadows and Seeps (Vernally Mesic), Valley and Foothill Grasslands (Subalkaline Flats)	Yes	No
( <i>Buxbaumbia viridis</i> )			Soil in Coniferous Forests, Sometimes Rotten Logs or Wood	No	No
Brandegee's Clarkia ( <i>Clarkia biloba</i> ssp. <i>brandegeae</i> )	-	CNPS 1B.2	Chaparral, Cismontane Woodland, Lower Montane Coniferous Forests	No	No
Dwarf Downingia ( <i>Downingia pusilla</i> )	-	CNPS 2.2	Valley and Foothill Grasslands (Mesic), Vernal Pools	Yes	Yes, NW boundary
Ahart's Buckwheat ( <i>Eriogonum umbellatum</i> var. <i>ahartii</i> )	-	CNPS 1B.2	Serpentinite, Slopes, Openings in Chaparral and Cismontane Woodlands	No	Likely, NW boundary
Pine Hill Flannelbush ( <i>Fremontodendron decumbens</i> )	Endangered	CR, CNPS 1B.2	Gabbroic or Serpentinite, Rocky Areas in Chaparral or Cismontane Woodlands	No	No
Butte County Fritillary ( <i>Fritillaria eastwoodiae</i> )	-	CNPS 3.2	Openings in Chaparral, Cismontane woodlands, and Lower Montane Coniferous Forest, Sometimes Serpentinic	No	No
Woolly Rose-mallow ( <i>Hibiscus lasiocarpus</i> var. <i>occidentalis</i> )	-	CNPS 1B.2	Freshwater Marshes and Swamps	Yes	Yes
Ahart's Dwarf Rush ( <i>Jucus leiospermus</i> var. <i>ahartii</i> )	-	CNPS 1B.2	Valley and Foothill Grasslands (Mesic)	Yes	Yes

Common Name ( <i>Scientific Name</i> )	Federal Status	State Status	Habitat Requirements	Habitat within District?	Known Occurrences within District?
Colusa Layia ( <i>Layia septentrionalis</i> )	-	CNPS 1B.2	Chaparral, Cismontane Woodlands, Valley and Foothill Grassland	Yes	No, although possible
Legenere ( <i>Legenere limosa</i> )	-	CNPS 1B.1	Vernal Pools	Yes	Yes
Veiny Monardella ( <i>Monardella douglasii</i> var. <i>venosa</i> )	-	CNPS 1B.1	Cismontane Woodlands, Valley and Foothill Grassland with Heavy Clay	Yes	Likely extirpated
Baker's Navarretia ( <i>Navarretia leucocephala</i> ssp. <i>bakeri</i> )	-	CNPS 1B.1	Mesic areas in Cismontane Woodlands, Lower Montane Coniferous Forests, Meadows and Seeps, Valley and Foothill Grasslands, Vernal Pools	Yes	Yes
Layne's Ragwort ( <i>Packera layneae</i> )	Threatened	CR, CNPS 1B.2	Gabbroic or Serpentine, Rocky Areas in Chaparral or Cismontane Woodlands	No	No
Cedar Crest Popcorn-flower ( <i>Plagiobothrys glyptocarpus</i> var. <i>modestus</i> )	-	CNPS 3	Cismontane Woodlands, Valley and Foothill Grassland (Mesic)	Yes	Only one historical site known
Hartweg's Golden Sunburst ( <i>Pseudobahia bahiaefolia</i> )	Endangered	CE, CNPS 1B.1	Clay (Often Acidic) in Cismontane Woodlands and Valley and Foothill Grassland	Yes	Yes
Sticky Pyrrocoma ( <i>Pyrrocoma lucida</i> )	-	CNPS 1B.2	Alkaline Clay in Great Basin Scrub, Lower Montane Coniferous Forests, Meadows and Seeps	No	No
Brownish Beaked-rush ( <i>Rhynchospora capitellata</i> )	-	CNPS 2.2	Mesic Upper and Lower Montane Coniferous Forests, Meadows and Seeps, Marshes and Swamps	Yes	No



Common Name ( <i>Scientific Name</i> )	Federal Status	State Status	Habitat Requirements	Habitat within District?	Known Occurrences within District?
San Francisco Campion ( <i>Silene verecunda ssp. verecunda</i> )	-	CNPS 1B.2	Sandy Areas in Coastal Bluff Scrub, Chaparral, Coastal Prairie, Coastal Scrub, and Valley And Foothill Grassland	Yes	No
Wright's Trichocoronis ( <i>Trichocoronis wrightii</i> var. <i>wrightii</i> )	-	CNPS 2.1	Alkaline Meadows and Seeps, Marshes and Swamps, Riparian Forests, and Vernal Pools	Yes	Yes
Siskiyou Mountains Huckleberry ( <i>Vaccinium coccineum</i> )	-	CNPS 3.3	Upper and Lower Montane Coniferous Forest, often Serpentinetic	Unknown	Unknown
El Dorado County Mule Ears ( <i>Wyethia reticulata</i> )	-	CNPS 1B.2	Clay or Gabbroic Areas in Chaparral, Cismontane Woodlands, and Lower Montane Coniferous Forests	No	No

CNPS = California Native Plant Society; List 1A: Presumed extinct in California; List 1B: Plants rare, threatened, or endangered in California and elsewhere; List 2: plants rare, threatened, or endangered in California, but more common elsewhere; List 3: Plants about which more information is needed; List 4: Plants of limited distribution – Watch List.

## Appendix B

California Department of Fish & Game  
North Central Region  
1701 Nimbus Road  
Rancho Cordova, CA 95670  
(916) 358-2912

California EPA  
1001 I Street  
P.O. Box 2815  
Sacramento, CA 95812

U.S. Army Corps of Engineers  
Sacramento District  
1325 J Street  
Sacramento, CA 95814  
(916) 557-7490

U.S. Fish & Wildlife Service  
2800 Cottage Way, Room W-2605  
Sacramento, CA 95825  
(916) 414-6600