MOSQUITO REDUCTION BEST MANAGEMENT PRACTICES

SACRAMENTO-YOLO
MOSQUITO
& VECTOR
CONTROL
DISTRICT

MOSQUITO REDUCTION BEST MANAGEMENT PRACTICES

These Mosquito Reduction Best Management Practices (BMPs) are compiled from a number of sources including scientific literature, collaborative inter–agency documents, and from experienced vector control professionals. 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 specific BMP Implementation Plan for specific mosquito source in consultation with District personnel.

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The Sacramento–Yolo Mosquito and Vector Control District (District) recognizes that certain land management practices can reduce mosquito populations thereby reducing long–term mosquito treatment costs, reducing the amount of pesticides used in mosquito control operations, helping to protect public health, and contributing to the District's integrated pest management (IPM) approach to mosquito and vector control.

Integrated Pest Management is an approach that focuses on site–specific, scientifically sound decisions to manage pest populations by matching a wide variety of techniques with the conditions found on site. These techniques are commonly grouped into four categories:

1. Source reduction or physical control—environmental manipulation that results in a reduction of mosquito development sites
2. Biological Control—use of biological agents to limit larval mosquito populations
3. Chemical Control—larvicides (materials that kill immature larval mosquitoes) and adulticides (materials that kill adult mosquitoes)
4. Cultural Control—change the behavior of people so that their actions prevent the development of mosquitoes or the transmission of vector–borne disease.

Through the adoption of these policies and procedures, the District would like to enhance the clarity of its efforts to effectively control mosquitoes by physical, cultural, and biological means. To this end, this document includes District guidelines for land–management practices that provide landowners and land managers an opportunity to address any land–based mosquito problems as may be identified by the District.

The Mosquito Reduction Best Management Practices (BMPs) referred to in this document are the recommended land management practices that can provide a reduction in mosquito populations by various means including: reducing or eliminating breeding

areas, increasing the efficacy of biological controls, increasing the efficacy of chemical controls, and improving access for control operations. These BMPs have been circulated among representatives of stakeholder groups including landowners, land managers, regulatory agencies, and other interest groups. As a result of the comments and suggestions received from this process, the District has a good understanding of practical and appropriate BMPs for a variety of land uses that exist in Sacramento and Yolo counties. Not all BMPs included in this document will apply equally to all mosquito sources; however the BMPs listed serve as a starting point in the cooperative development of site–specific BMP Implementation Plans that will address particular mosquito sources.

The District intends to encourage those responsible for significant mosquito sources on their property to develop and implement a cooperative Mosquito Reduction BMP plan with the District to avoid the need for formal enforcement actions authorized under the California Health and Safety Code (HSC)[1]. While in some situations, the District must employ the California Health and Safety Code in order to ensure safe conditions and to carry out its public responsibilities, it has been the District's experience that a cooperative approach provides more effective and long–lasting mosquito management.

The Mosquito Reduction BMP Implementation Policies are designed to address mosquito breeding sources including, but not limited to: managed wetlands, duck clubs, rice fields, agricultural ditches, stormwater structures, wastewater facilities, residential properties, and cemeteries. Many of these sources produce significant mosquitoes due to management practices that promote favorable habitat for mosquitoes.

While it is generally accepted that mosquito production from all sources may be reduced through the widespread implementation of Mosquito Reduction BMPs, these policies specifically target the most severe mosquito problems with the greatest likelihood of responding through the use of BMPs. These sources are defined as Significant Mosquito Sources, and will be addressed according to the following policies and procedures. For those properties with mosquito sources that do not fit the definition of Significant Mos-

[1]Under the California Health and Safety Code, mosquito and vector control districts may legally abate a 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." (HSC §2002(j)). Abatement can result in civil penalties of up to $1000.00 per day (HSC §2085(a), §2061).

quito Source, the BMPs offer an opportunity to proactively address mosquito problems to avoid development into a significant mosquito source.

In cases where the implementation of Mosquito Reduction BMPs would cause economic hardship or cause technical difficulties, the District may choose to offer assistance in the form of equipment, labor, technical advice, or other resources. The level of assistance offered will be determined on a case by case basis.

SIGNIFICANT MOSQUITO SOURCES

Significant Mosquito Sources will be identified based on the following criteria:

- Mosquito production from the source is more than similar land uses, and exceeds treatment thresholds;
- Treatment costs incurred by the District are increased due to problems caused by management practices;
- The source is in close proximity to areas of significant population density; and/or
- BMPs exist to address the land management practices and can be reasonably utilized to reduce mosquito production.

If left untreated, a Significant Mosquito Source would be considered a public nuisance as defined in the California Health and Safety Code (HSC) §2002(j).

A combination of larval dip data and adult mosquito surveillance data will be used determine the pre and post BMP implementation mosquito abundance for a particular property or mosquito source. In cases where existing data or current sampling methods are not sufficient to detect the efficacy of a particular BMP, a specific monitoring plan will be established to meet the needs of the particular property or mosquito source.

Management practices that would contribute to increased mosquito production include but are not limited to: poor water management, lack of emergent vegetation control, lack of effective refugia to maintain biological control populations (e.g. borrow pits), poor condition of water conveyance or drainage structures, practices that impede access to the source, and lack of notification of practices that would effect mosquito control operations.

Other factors such as treatment costs, proximity to population centers, vector–borne disease status, mosquito species produced, and the efficacy of available treatment options will be considered when evaluating a Significant Mosquito Source as defined above. Those sources that are determined to have the highest potential for mosquito reduction from the implementation of BMPs and are adjacent to population centers of reasonably high density will be selected for inclusion into the BMP compliance program.

BMP IMPLEMENTATION PLAN

Once the District has identified a Significant Mosquito source, it will present a draft BMP Implementation Plan to the responsible party, in consultation with state and federal biologists if appropriate, proposing a course of action based on one or more BMPs that, if implemented, can reduce or eliminate the mosquito breeding sources.

The draft BMP Implementation Plan will contain at least the following:

- Justification for requested actions.
- Description of the proposed BMPs including specific guidance regarding method and timing of implementation.
- District resources available to assist with BMP Implementation.
- Assessment method.

The responsible party will have the opportunity to review and comment on the draft plan. Reasonable adjustments may be negotiated between the responsible party and the District to achieve a mutually agreeable plan. A reasonable time limit will be set at the beginning of the negotiation phase at which time the District will finalize any unresolved issues at its discretion. This time limit may be extended if all parties agree that there is reasonable cause to do so.

If the responsible party is unwilling to accept the terms of this cooperative process, the District may be forced to pursue an enforcement process including abatement.

CHARGES FOR TREATMENT COSTS

The District is authorized by the Health and Safety Code to recover treatment costs for mosquito control operations. Since most treated properties in the District pay for a base level of mosquito control through the payment of property taxes, the District would consider charging for treatment cost that are above and beyond the normal level of treatment required by a similar mosquito source with similar land use. Since one of the primary goals of the BMP Policies is to reduce pesticide use in Sacramento and Yolo counties, 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 is reserched further, the expectation would be that the charge for treatment portions of the BMP Implementation Plans would be replaced by non–pesticide based long–term mosquito management plans.

APPEAL PROCESS

The responsible party may submit comments in writing to the District Board of Trustees of the District before the implementation deadline indicated on the Draft BMP Implementation Plan presented to the responsible party in Step #2 on Figure 1. After review, the Board will issue a determination which may include no change in the content of the Draft BMP Implementation Plan, an extension of the implementation deadline, a waiver of fees, or other appropriate action.

If the responsible party is a state agency, appeals may be made to the State Department of Health Services pursuant to the California Health and Safety Code.

BMP IMPLEMENTATION PROCESS FOR SIGNIFICANT MOSQUITO SOURCES

The following items are a generally chronological progression of the Mosquito Reduction BMP Compliance Program actions after a Significant Mosquito Source is identified.

NOTE: *The numbered items correspond to the numbers on Figure 1.*

1. **IDENTIFY A SIGNIFICANT MOSQUITO SOURCE**—The District will identify Significant Mosquito Sources based on the previously defined criteria.

2. **CONTACT RESPONSIBLE PARTY**—The District will contact the responsible party (as defined in HSC §2060) of properties in Sacramento or Yolo county that have been identified as significant mosquito sources, that if untreated, would become a public nuisance (under HSC §2060). The Department will also contact state and federal agencies that have an underlying interest in the property, including a conservation easement, habitat management plan, or other habitat maintenance agreement. A draft BMP Implementation Plan will be provided to the responsible parties. This plan will include an explanation of why the site was determined to be a significant mosquito source, including mosquito surveillance data if requested

3. **NEGOTIATE BMP IMPLEMENTATION PLAN**—The District's Ecological Management Department will work with the responsible party to achieve a mutually agreeable course of action to address the mosquito source including specific BMPs, implementation timeline, maintenance requirements, and monitoring plan. A defined negotiation period will be designated at the start of the negotiations.

4. **ADDITIONAL RESOURCES**—At the discretion of the District, resources may be made available to assist in complying with the BMP requirements. In cases where District resources are used, specific maintenance requirements will be specified in the cooperative agreement, and will be signed by the responsible party and the District. This Agreement will contain the name of the responsible party, location of the property, description of the work to be done, the cost of the work, if

any, to be paid by the responsible party, and requirements for maintenance to be performed by the responsible party. In some cases, such as maintaining access to dairy sumps by regular mowing, the District will use a Vegetation Control Agreement to establish a long–term contract with each dairy operator. This agreement shall be subject to the same requirements as any other agreement covered by these policies.

5. **COORDINATE WITH OTHER REGULATORY AGENCIES**—Other local, state, federal, and conservation agencies will be brought into the negotiation process to avoid or address any potential regulatory conflicts with the draft BMP Implementation Plan.

6. **COOPERATIVE AGREEMENT**—The cooperative agreement will formalize the relationship between the District and the responsible party holding both to the terms agreed upon in the BMP Implementation Plan. This document will also outline the consequences of non–compliance with the BMP Implementation Plan under the California Health and Safety Code.

7. **IMPLEMENTATION AND MONITORING**—After successful implementation of the requirements, regular inspections of the property will be conducted to assess the responsible party's continued maintenance and compliance with the BMPs. The District reserves the right to re–negotiate the BMP Implementation Plan if it is discovered that adequate mosquito control is not being achieved. In this case, the process would return to Step 2. As long as the responsible party is in compliance with the terms of the cooperative agreement, no additional charges or penalties will be assessed by the District.

8. **EVALUATION OF BMP EFFICACY—**An effective mosquito management plan requires regular assessment and adaptive management to address changing conditions or unforeseen effects. The District will evaluate each BMP Implementation Plan to determine if the BMPs are meeting the needs of both the responsible party and the District. Based on this evaluation, either party may initiate a review of the BMP Implementation Plan pursuant to the terms of the cooperative agreement.

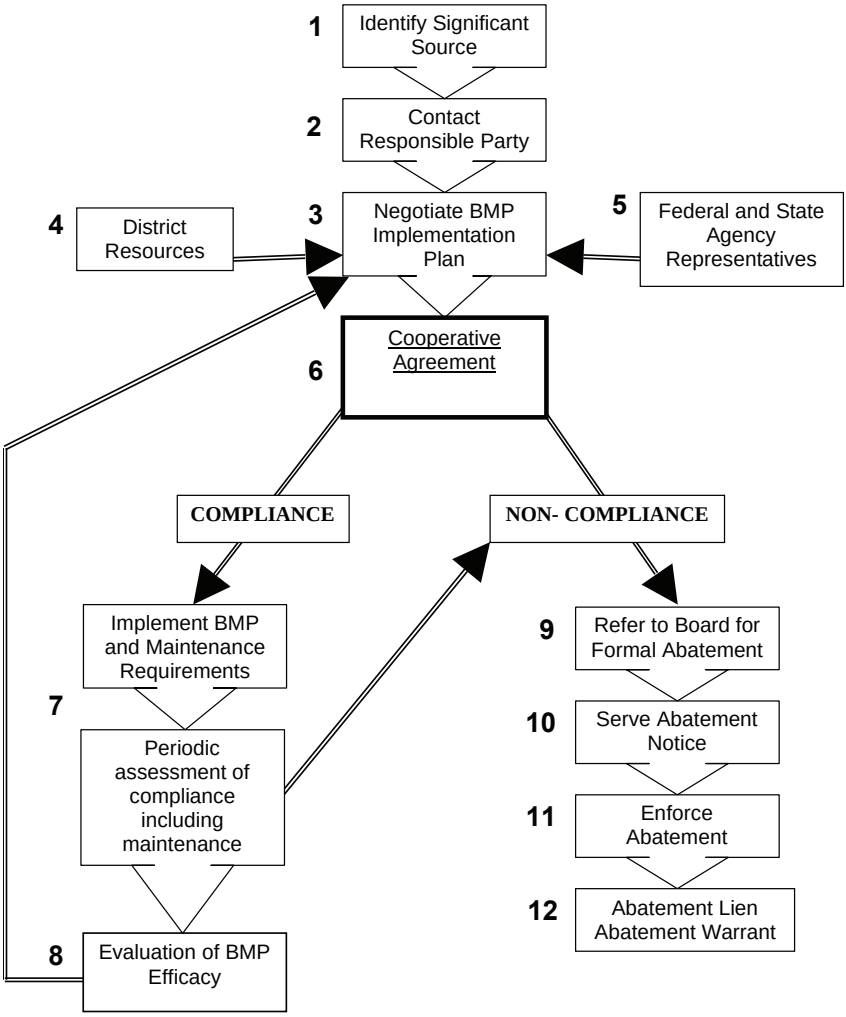
9. **ABATEMENT PROCESS**—If the responsible party does not take corrective action or does not provide a reasonable explanation for the continued lack of compliance with the cooperative agreement, the case may be brought to the District Board of Trustees to begin the Formal Abatement process as defined in HSC §2061.

10. **SERVE ABATEMENT NOTICE**—Under guidance from of the District Board of Trustees, the responsible party will be served an abatement notice directing them to comply with the cooperative agreement within the specified timeframe. Civil penalties of up to $1000 per day will be imposed for non–compliance pursuant to §2061 and §2063 of the California Health and Safety Code

11. **ENFORCE ABATEMENT**—Under the 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." HSC §2065(b) .

12. **ADDITIONAL ABATEMENT ACTIONS**—Under the direction of the District Board of Trustees, and/or manager, other measures such as an abatement warrant or abatement lien may be imposed pursuant to the California Health and Safety Code.

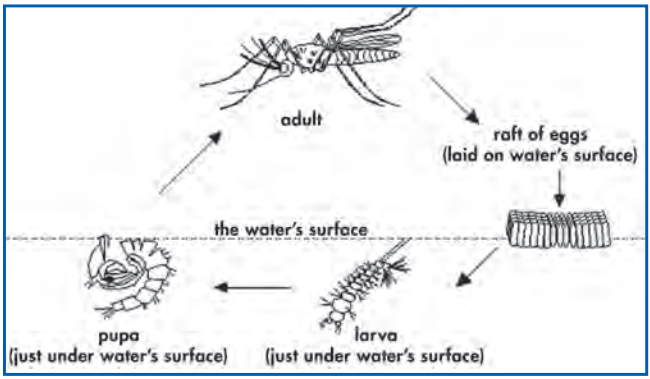
FIGURE 1: **BMP PROGRAM FLOWCHART**



BASIC MOSQUITO BIOLOGY

There are over 50 different species of mosquito in California. Fortunately, only a handful are of significant concern in our area. It is important to realize that each species of mosquito has different habitat requirements and behaviors that affect its ability to transmit disease, bite humans, and be controlled by a specific BMP.

BASIC MOSQUITO LIFE CYCLE



All mosquitoes share a similar life cycle with an aquatic stage (larvae) and an aerial stage (adult). Nearly all mosquito reduction best management practices (BMPs) focus on managing the aquatic stage of the mosquito by creating the conditions less favorable for mosquito development. This usually involves manipulating the amount or timing of standing water, decreasing the amount of vegetation in and around the standing water, and creating a situation where natural or introduced predators can consume the mosquito larvae. Since each species of mosquito has slightly different habitat requirements, it is important to understand which mosquitoes favor which habitats to realize how a particular BMP is designed to work.

To understand BMPs it is useful to think of mosquitoes as belonging to one of the following three categories. Examples of common species within each category follow.

1. **STANDING–WATER MOSQUITOES** prefer still water commonly found in ponds, un–maintained swimming pools, rice fields, puddles, etc.

   Common Mosquito Reduction BMPs:

   a. Drain standing water.
   b. Reduce or eliminate emergent vegetation in and along the edges of the water.
   c. Hold water level constant to encourage natural predators or biological control agents (e.g. mosquitofish).
   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 in moist soil. When they become submerged as in a seasonal wetland or irrigated pasture, the eggs hatch.

   Common Mosquito Reduction BMPs:

   a. Flood when air temperatures do not encourage rapid mosquito development (e.g. late fall rather than summer).
   b. Reduce or eliminate emergent vegetation by disking or mowing.
   c. Flood quickly to encourage all eggs to hatch at once and minimize the need for multiple larvicide applications.
   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, etc. Some standing water mosquitoes will also develop in containers such as the House Mosquito (*Culex pipiens*).

   Common Mosquito Reduction BMPs:

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

STANDING–WATER MOSQUITOES

ENCEPHALITIS MOSQUITO (*Culex tarsalis*)

The Encephalitis Mosquito can transmit encephalitis viruses to humans. It has been known to transmit West Nile virus, Western Equine Encephalomyelitis virus and St. Louis encephalitis virus. The Encephalitis Mosquito can be found throughout Sacramento and Yolo counties. Immature mosquitoes develop in wetlands, duck clubs, rice fields and irrigated crops. The adult mosquito prefers to feed on birds and mammals. It is most active during summer and fall.

NORTHERN HOUSE MOSQUITO (*Culex pipiens*)

The Northern House Mosquito has been known to transmit West Nile virus and St. Louis encephalitis virus. It is common throughout Sacramento and Yolo counties. Immature mosquitoes often develop in foul water sources such as dairy lagoons, storm drains, un–maintained swimming pools, cemetery vases and other containers. It prefers to feed on birds but will readily feed on humans. This mosquito is most active during the summer and fall.

WESTERN MALARIA MOSQUITO (*Anopheles freeborni*)

Anopheles freeborni can transmit the malaria parasite to humans. It is common in rice growing regions of California. Immature stages develop in rice fields, wetlands, duck clubs and rain pools. While malaria does not normally occur in California anymore, this mosquito allows the potential for local outbreaks of malaria if a person gets infected elsewhere, and then is bitten by a local *Anopheles* mosquito.

FLOODWATER MOSQUITOES

WETLANDS MOSQUITO (*Aedes melanimon*)

Aedes melanimon is involved in the encephalitis transmission cycle and is a severe outdoor pest. It is common in Sacramento and Yolo counties. This mosquito develops in wetlands, duck clubs and irrigated pastures. It prefers to feed on mammals. It is most active during the fall and spring.

INLAND FLOODWATER MOSQUITO (*Aedes vexans*)

This mosquito is a secondary vector for dog heartworm and is a severe outdoor pest. It is common in irrigated pastures and in woodland water course pools. They feed primarily on mammals. This mosquito is most active in early spring through late fall. They typically blood feed at dawn and dusk, but may also be active during the day.

CONTAINER MOSQUITOES

WESTERN TREEHOLE MOSQUITO (*Aedes sierrensis*)

This mosquito can transmit the dog heartworm parasite (*Dirofilaria immitis*), and is a severe outdoor pest. The western treehole mosquito is common in oak woodlands. Immature stages develop in tree rot holes. Female adults feed primarily on mammals, and are most active during late winter through early spring.

ASIAN TIGER MOSQUITO (*Aedes albopictus*)

This species of mosquito has not established in California yet, but is an aggressive exotic species that has invaded the eastern and southern US. Over the past 10 years there have been several cases where this mosquito was found in cargo containers in port areas in Los Angeles and San Francisco. This container breeding species is a potential vector for various vector–borne diseases such as Rift Valley Fever, Chikungunya Virus, Dengue Fever, and Yellow Fever. Should *Aedes albopictus* become established in California, the need for effective mosquito control practices will be even more important to protect public health.

AGRICULTURAL IRRIGATION AND DRAINAGE

These Mosquito Reduction Best Management Practices (BMPs) are compiled from a number of sources including scientific literature, collaborative inter–agency documents, and from experienced vector control professionals. 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 specific BMP Implementation Plan for a specific mosquito source in consultation with District personnel.

COMMON MOSQUITO DEVELOPMENT SITES

- Vegetated ditches
- Seepage or flooding of fallow fields
- Irrigation tail water return sumps
- Blocked ditches or culverts
- Leaky water control structures
- Irrigated pastures
- Low areas caused by improper grading
- Broken or leaky irrigation pipes or valves

COMMON MOSQUITO SPECIES

- Clean standing water sources: *Culex tarsalis*
- Nutrient rich water sources: *Culex pipiens*
- Seasonally flooded areas: *Aedes* species *(Ae. melanimon)*

SPECIAL CONCERNS

Agricultural practices vary among growers, locations, and conventional or organic production methods. Pesticide regulations can affect the ability to use chemical control The Mosquito Reduction Best Management Practices below are offered as tools to balance the economic and agronomic requirements of the growers and land owners with the need for effective mosquito control. The District is committed to working with growers to implement mosquito control practices that coincide with agricultural practices and minimize the impact on the economics or yields of the crop.

General Mosquito Reduction Principles

1. Prevent or eliminate unnecessary standing water that stands for more than 72 –96 hours during mosquito season which can start as early as March and extend through October depending on weather.
2. Maintain access for District staff to monitor and treat mosquito breeding sources.
3. Minimize emergent vegetation and surface debris on the water.
4. Contact the District for technical guidance or assistance in implementing mosquito reduction BMPs.

MOSQUITO REDUCTION BMPS FOR AGRICULTURAL SETTINGS

DITCHES AND DRAINS

DD-1. Construct or improve ditches with at least 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 prevent unwanted vegetation growth. Other designs may be approved by the MVCD 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 over fertilize. 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 provide 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 hoof prints of livestock that were run on wet fields or left in the field during irrigation. Keeping animals off wet fields until soils stiffen also protects the roots of the forage crop and prevents soil compaction that interferes with plant growth (Lawler and Lanzaro, 2005).

IP-8. Break up pastures into a number of smaller fields so that the animals can be rotated from one field to another. This allows fields to dry between irrigations and provides a sufficient growth period between grazings. 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 DEVELOPMENT SITES

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

COMMON MOSQUITO SPECIES

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

SPECIAL CONCERNS

Dairy and associated agricultural practices vary; however, these practices need to take into account mosquito and vector control issues. The Best Management Practices for Mosquito Reduction below offer options to balance the requirements of the 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 MOSQUITO REDUCTION PRINCIPLES

1. Prevent or eliminate unnecessary standing water that remains for more than 72 –96 hours during mosquito season which can start as early as March and extend through October depending on weather.
2. Maintain access for District staff to monitor and treat mosquito breeding sources.
3. Minimize emergent vegetation and surface debris on the water.
4. Contact the District for technical guidance or assistance in implementing mosquito reduction BMPs.

SPECIFIC MOSQUITO REDUCTION BMPS

DA-1. Wastewater holding ponds should not exceed 150' in width.

DA-2. All holding ponds should be surrounded by lanes of adequate width to allow safe passage of vector control equipment. 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 the holding ponds, it should be placed on the outside of the lanes 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. Drainage lines should never by–pass the separator ponds, except those that provide for normal corral run–off and do not contain solids. All drain inlets must be sufficiently graded to prevent solids accumulation.

DA-7. Floating debris should be eliminated on all ponds; mechanical agitators may be used to break up crusts.

DA-8. 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. An approved vegetation management plan should be on file with the District.

DA-9. Dairy wastewater discharged for irrigation purposes should be managed so that it does not stand for more than three days.

DA-10. All structures and water management practices should meet current California Regional Water Quality Control Board requirements (Creedon, 2006).

DA-11. 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 DEVELOPMENT 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 available chemical control materials available, so additional attention to BMPs is critical.
- Leaky levees
- Weedy borrow pits and field borders
- Irrigation and drain ditches

COMMON MOSQUITO SPECIES

- *Culex tarsalis*
- *Anopheles* species

SPECIAL CONCERNS

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 land owners with the need for effective mosquito control. The District is committed to continue working 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 is important with all rice growers, but is especially important with growers who produce organic rice. At this time, there is only one available mosquito larvicide for organic rice which leaves biological control (mosquito fish), 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 IPM program, the District asks organic rice growers for an added level of commitment to addressing mosquito control issues in a cooperative manner.

MOSQUITO REDUCTION BMPS FOR RICE FIELDS

RI-1. Wherever feasible, maintain stable water level during mosquito season by ensuring constant flow of water into pond or rice field 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 mosquito fish or to use alternative mosquito control measures.

RI-5. Wherever feasible, maintain 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 your county mosquito control officials 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 mosquito fish during low water.

CONVENTIONAL RICE PRODUCTION

RI-9. Notify MVCD prior to any pyrethroid insecticide applications to rice fields stocked with mosquito fish. 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).

ORGANIC RICE PRODUCTION

RI-10. Wherever feasible, maintain borrow pits (12″–18″ deep) on both sides of each check throughout rice fields to provide refuge for mosquito fish during low water periods.

STORMWATER SYSTEMS

COMMON MOSQUITO DEVELOPMENT SITES

- Detention/retention basins
- 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

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

SPECIAL CONCERNS

With the National Pollution Discharge Elimination System (NPDES) permit requirements taking the spotlight in the stormwater quality community, the fact that stormwater 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 development in stormwater 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 MOSQUITO REDUCTION PRINCIPLES

1. Maintain access for District staff to monitor and treat mosquito breeding sources.
2. Minimize emergent vegetation or surface debris in the water.
3. Contact the District for technical guidance or assistance in implementing mosquito reduction BMPs.
4. Contact the District for technical guidance or assistance in implementing mosquito reduction BMPs.

MOSQUITO REDUCTION BMPS FOR STORMWATER SYSTEMS

ABOVE GROUND STRUCTURES

SW-1. Build shoreline perimeters as steep and uniform as practicable to discourage dense plant growth (Metzger, 2004).

SW-2. Whenever possible, maintain stormwater ponds and wetlands at depths in excess of 4 feet (1.2 m) 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., fish) 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 stormwater 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 (6 m) 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 above–ground structures that are less than 25 feet (7.5 m) 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

stormwater 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 [12 m]) 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 remain 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 STRUCTURES (SUMPS, VAULTS, DROP INLETS, 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. Stormwater structures utilizing covers should be tight fitting with maximum allowable gaps or 1/16 inch (2 mm) holes of 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 if necessary (Metzger, 2004).

MANANGED WETLANDS

COMMON MOSQUITO DEVELOPMENT SITES

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

COMMON MOSQUITO SPECIES

- Permanent wetlands: *Culex tarsalis*
- Seasonal wetlands: *Aedes* species

SPECIAL CONCERNS

Managed wetlands are being built and restored across northern California. Each varies depending on the habitat, water quality, recreational, economic, and other management goals, and may be subject to additional regulations including state and federal conservation easements and management plans. Mosquito Reduction BMPs attempt to balance the management goals of land managers, land owners, 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 MOSQUITO REDUCTION PRINCIPLES

1. Maintain access for District staff to monitor and treat mosquito breeding sources.
2. Minimize emergent vegetation and surface debris on the water.
3. Contact the District for technical guidance, assistance in implementing mosquito reduction BMPs, or to coordinate flood–ups with mosquito control operations.

SPECIFIC MOSQUITO REDUCTION BMPS

DESIGN AND MAINTENANCE

MW-1. Maintain all open ditches by periodically regularly 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 technician 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 flow, 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 prevent unwanted vegetation growth (Kwasny et. al., 2004). Other designs may be approved by the District depending on special circumstances.

MW-6. Construct, or improve, or maintain levees to quality standard that ensures stability and prevents unwanted seepage. Ideally build levees with >3:1 slopes & >80% compaction; consider >5:1 slope or greater in areas prone to over–land flooding and levee erosion (Kwasny et. al., 2004).

MW-7. Ensure 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. 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).

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 allow good penetration of chemical control agents. (Kwasny et. al., 2004)

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 mosquito fish or other invertebrate predators. Water from permanent ponds can be used to passively introduce mosquito predators (Kwasny et. al., 2004).

MW-19. Rapidly irrigate wetlands keeping the time water enters the pond to complete drawdown between 4 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).

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 re–flood 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, draw–down 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 draw–down 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 passively transport predators to newly flooded habitats (Kwasny et. al., 2004).

MW-32. Maintain permanent or semi–permanent 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 DISTRICT

MW-35. Consult with the District on agency–sponsored habitat management plans on private lands (e.g. Presley Program), and 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 effecting mosquito production or control operations (Kwasny et. al., 2004).

URBAN AND SUBURBAN MOSQUITO SOURCES

COMMON MOSQUITO DEVELOPMENT SITES

- Un–maintained 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
- Koi ponds
- Stored or waste tires

COMMON MOSQUITO SPECIES

- Cleaner water sources: *Culex tarsalis*
- Water with more organic material*: Culex pipiens*

SPECIAL CONCERNS

Urban and suburban mosquito sources are especially important because, sources may be in and around private residences which are not easily seen or accessed by control technicians and 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. Economic or social changes in a neighborhood can result in an increase in mosquito sources such as un–maintained swimming pools. Fortunately, many of the BMPs for residential areas are relatively inexpensive and easy to implement.

GENERAL MOSQUITO REDUCTION PRINCIPLES

1. Prevent or eliminate unnecessary standing water that remains for more than 72 –96 hours during mosquito season which can start as early as March and extend through October depending on weather.
2. Maintain access for District staff to monitor and treat mosquito breeding sources.
3. Contact the SYMVCD for technical guidance or assistance in implementing mosquito reduction BMPs.

SPECIFIC MOSQUITO REDUCTION BMPS

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 district so that the pool can be inspected regularly and treated with a larvicide and/or stocked with mosquito fish if needed.

US-4. Notify 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 biologically control mosquito larvae.

US-5. Landscape irrigation drainage should be managed such that no water stands for more than 72 hrs during mosquito breeding season (generally April–October).

US-6. All underground drain pipes should be laid to grade to avoid low areas that may hold water for longer than 72 hrs.

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, leaking outdoor faucet if unable to be fixed or 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 inspections 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 and dump out any water that may have accumulated inside tires on their premises on a weekly basis.

CEMETERY FLOWER VASES

CV-1. Use a water–absorbing polymer material (super–absorbent polyacrylamide) which turn 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 which can hold water for 72–96 hours.

CV-3. Dump out all vases weekly during the spring, summer, and fall.

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SACRAMENTO-YOLO
MOSQUITO
& VECTOR
CONTROL
DISTRICT

FIGHT THE
BITE

OFFICE LOCATIONS AND HOURS OF OPERATION

SACRAMENTO COUNTY
8631 Bond Road
Elk Grove, CA 95624
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Fax: 916-685-5464
Web site: FIGHTtheBITE.net
Hours: 7:00 a.m. to 3:30 p.m.

YOLO COUNTY
1234 Fortna Avenue
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Phone: 1-800-429-1022
Fax: 530-668-3403
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Hours: 7:00 a.m. to 3:30 p.m